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IS THERE SUPPLY DISTORTION IN THE GREEN BOX? AN ACREAGE RESPONSE APPROACH

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1 Introduction

In the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), the distortionary effects of domestic farm programs figured high on the negotiating agenda. Along with the export subsidies and market access, domestic farm policies were targeted for reductions in support. Under the Uruguay Round Agreement on Agriculture (URAA), domestic support is classified into three categories or boxes according to their supposed impact on international trade. According to URAA conventions, the amber-box contains the most distorting subsidies, and, hence, limits to their use have been agreed. Blue-box payments also cause some distortion but are required to be production limiting. The green-box contains subsidies that are classified as being minimally trade distorting. The subsidies in the blue- and green-boxes are excluded from all World Trade Organization (WTO) disciplines – are excluded from the Aggregate Measure of Support – and are expected to have no, or at most minimal, trade-distorting effects on production. Decoupled support policies which are defined as payments that are financed by taxpayers and are not related to current production, factor use, or prices, and for which eligibility criteria are defined by a fixed, historical base period, are categorized as green-box payments. Since they are exempt from WTO disciplines, payments considered to be decoupled have been providing a growing and important share of the total support to agriculture provided by governments. The extent to which exempted policies really are production and trade neutral has, however, recently come under increasing scrutiny. It is hypothesized that there are various mechanisms by which decoupled payments may affect production decisions.

The literature addresses six major channels through which decoupled payments could affect production. They ease credit constraints faced by farmers (when capital market are imperfect); they affect the labour allocation decisions of farm households (when labour market

are imperfect); they alter land values, rents and land prices or influence the entry and exit decisions of farmers; they influence farmers decisions through expectations about future payments; and they may affect the risk faced by farmers. Hennessy (1998) developed a theoretical framework for the analysis of agricultural income support policies under uncertainty. He showed that for decoupled payments, which tend to increase expected profit as well as to contract the variability of profit, decreasing absolute risk aversion is sufficient to ensure an increase in production. He introduced two effects of decoupled payments that would not arise in a certain world: the wealth effect and the insurance effect. The former means that the higher average income arising from the support policy may affect producer decisions. The latter refers to the income-stabilizing attribute that may affect optimizing decisions.

The main objective of this study is to investigate whether Canadian whole farm programs, which have been designed with the WTO rules in mind, are actually decoupled. To accomplish this objective, a theoretical and empirical framework which consider the risk effects of these types of programs is developed.

In this study the expected utility maximization model of Chavas and Holt (1990) is modified to examine the effects of Canadian support programs on acreage decisions for major crops in the prairie provinces over 1970-2006. By developing theoretical restrictions, we contribute to the literature on supply response by adding the insurance effect (income stabilization) emphasized in the literature (Hennessy, 1998), which was ignored by Chavas and Holt model (1990), into our theoretical model. Hence, the acreage response equation is specified as a function of expected crop profits, elements of the variance-covariance matrix of profits, expected total wealth – initial wealth plus market profit, and variance of total wealth, among other variables. Furthermore, government payments are incorporated into the model through

truncation of the probability distribution of profits. Specifically, the whole-farm programs truncate the total (farm) profit distribution which affect the expected total wealth and variance of total wealth. Within this model, a system of nine crop equations is provided and all the relevant elasticities of acreage allocation with respect to the exogenous variables are estimated. If the coefficient of expected total wealth and variance of total wealth variables are statistically significant (insignificant) in the whole system, the whole-farm programs are (are not) production and therefore trade distorting and are not (are) decoupled. The statistically significant coefficient are used to simulate the impact of recent whole-farm programs – the Net Income Stabilization Account (NISA) and the Canadian Agricultural Income Stabilization (CAIS) – on crop choices.

The next section presents a selected literature review. This is followed by the theoretical framework used in this study. Section 4 contains the empirical model with the data description and the results. Finally, conclusions and policy implications are presented in section 5.

2 Literature Review

While it can be theoretically shown that decoupled payments have no impact on farm profit maximization decisions in a deterministic world with perfect markets and risk neutral producers, an extensive literature suggests that payments designated as decoupled in the WTO can indirectly affect production and trade.

If credit markets are imperfect (for example, the existence of a significant gap between borrowing and lending rates and/or the presence of binding debt constraints for the farmer willing to invest), decoupled payments have the potential to increase the liquidity of credit constrained farmers and so will affect production decisions (Barry, Bierlen and Sotomayor, 2000; Roe, Somwaru, and Diao, 2003). The payments also increase land values and rents, which also improves the credit worthiness of credit-constrained farmers and lead them to keep land in

agriculture (Dewbre, Anton and Thompson, 2001; Frandsen, Gersfelt and Jensen, 2003; Goodwin, Mishra and Ortalo-Magne, 2003; Gohin, 2006). Decoupled payments affect farmer expectations by linking current decisions to future payments (Lagerkvist, 2005; McIntosh, Shogren and Dohlman, 2007; Coble, Miller and Hudson, 2007). Support programs that are directly based on previous production, e.g. output last year, have a built-in dynamic aspect, since the farmer can directly affect next year's payments with today's production decision. If labour market is imperfect (for example a wage gap between on-farm and off-farm returns), decoupled payments affect labour markets by influencing the on- and off-farm labour supply decisions and so will affect agricultural production (El-Osta, Mishra, and Ahearn, 2004; Ahearn, El-Osta, and Dewbre, 2006). In the presence of uncertainty, decoupled payments affects the total wealth of the farmer and this change in wealth can affect the farmers'attitude to risk (risk aversion). The way in which wealth affects risk aversion depends on assumptions concerning the utility function. If absolute risk aversion is reduced by the wealth effect (Decreasing Risk Absolute Aversion (DARA) assumption), farmers will be willing to assume more risk and therefore will produce more. Decoupled payments may affect the degree of risk faced by the farmer. The idea is that a policy reducing the risk faced by the farmer will have a positive effect on production. It can be proved that a government scheme that increases payments when prices fall and reduces payments when prices rise will increase production if there is partial income compensation for the price movements. Chavas and Holt ,1990; Massow and Weersink, 1993; Hennessy, 1998; Burfisher, Robinson, and Thierfelder, 2000; Serra, Zilberman, Goodwin, and Featherstone, 2006; Goodwin and Mishra, 2006; Coyle, Wei and Rude, 2008, among others, have examined the production impact of decoupled payments by incorporating risk. In what follows, we present some studies pertaining to the impact of decoupled payments on production through the use of a risk

mechanism.

Chavas and Holt (1990) study the impact of U.S. price support programs on acreage decisions under risk, for corn and soybeans from 1954 to 1985. They develop an acreage supply response model under an expected utility maximization of wealth framework for a farm household subject to budget and acreage constraints. They derive an optimal acreage decision for a farm household as a function of expected net returns for the own and competing crops, second moment of the distribution of the net returns, and initial wealth. Then, through examining theoretical restrictions, total wealth (initial wealth plus market returns) as well as expected crop net returns and variance-covariance of crop prices appears in the model specified for estimation. The effect of a price support program is incorporated into the model by truncation of the the price distribution.

Variances and covariances of crop prices (a proxy for risk) are found to be statistically significant in most cases. Elasticities with respect to initial wealth are statistically significant and 0.087 for corn and 0.270 for soybeans. The hypothesis of constant absolute risk aversion over the period of analysis for corn and soybean farmers is rejected and the positive wealth effect is consistent with decreasing absolute risk aversion. In order to show the importance of considering risk in a multicrop framework, the authors simulate the acreage response models at various price support levels for corn and soybeans. Due to the truncation effects, changing the support price levels will influence the means, variances and covariances of prices. The model simulations indicate that there is some range over which increasing the support price for corn will result in more acres planted to soybeans because the risk reducing effect of a price support program influencing acreage substitution dominates the mean price effect. This result emphasizes the importance of cross-commodity risk effects and the risk-reducing role of government support

payments.

Massow and Weersink (1993) assess the impact of government support programs on acreage response under price and production risk in the province of Ontario in Canada from 1965 to 1990. Following Chavas and Holt, they start from the maximization of the expected utility of wealth and derive the optimal acreage decisions as a function of initial wealth, expected profit for the own and competing crops, and the expectations of the higher moments of the profit distributions. In order to incorporate the effect of government programs, the authors truncate the subjective price and yield distributions at the support level. Estimation of the system of acreage response functions for white beans, corn, soybeans and winter wheat indicates that the signs of variables are generally consistent with theory. The change in acreage of all four crops due to changes in the expected variability of the revenues is less than acreage changes due to changes in levels of expected revenues, which shows the impact of risk relative to expected returns.

The null hypothesis that farmers are risk-neutral is rejected which indicates the need to include some measure of risk in acreage response models. The constant absolute risk aversion hypothesis is also rejected which implies the need to include a wealth variable in acreage response estimations. Using the estimated coefficients, the authors simulate various government policy scenarios over 1980-1989 to measure how any scenario will affect the average expected revenue and variability of revenue and therefore the crop acreages. The results indicate that the National Tripartite Stabilization Program (NTSP) had the most potential to affect acreage decisions, considerably increasing the level of white bean acreage by 24.3 per cent. The Agricultural Stabilization Act (ASA) increased average corn acreages by 2.9 per cent at the expense of the portfolio of alternative crops. Although the Gross Revenue Insurance Program (GRIP) had the least potential for misallocation of land among crops since it provided a

consistent measure of support to all of the crops, it produced an acreage response of 3.6 per cent, on average.

Miranda, Novak and Lerohl (1994) examine the effect of the Canadian Western Grains Stabilization Program (WGSP) on acreage response. They estimate a nonlinear rational expectations model of aggregate acreage supply (for six major grain crops) for the Canadian Prairie between 1976 and 1990 by accounting directly for a structural model of the WGSP in their estimation framework. An aggregate acreage supply equation is considered as a function of expected revenue and the variance of revenue. A system of grain market equations including grain price, grain marketings, on-farm dispositions, and yield is estimated. Using the estimated parameters which give the western Canadian grain market equations and nine deterministic structural equations which describe WGSP payouts, rational *ex ante* expectation and variance of per hectare revenues are computed by Gauss-Hermite numerical integration methods. Then, the effect of *ex ante* means and variance of per hectare revenues on acreage response is estimated. Finally, using the estimated coefficients, the impact of the WGSP on acreage decisions was simulated by computing *ex ante* means and variance of revenues with WGSP implementation and without WGSP implementation. The results indicate that the WGSP increased acreage planted to eligible crops by over 4 per cent during its 15 years of operation. Most of this increase (2.4 per cent) was related to the risk (variances of revenue) reduction effects of the program, the remainder (1.7 per cent) to increases in expected revenues.

Lin and Dismukes (2007) examine whether the Counter-Cyclical Payments (CCPs) in the U.S. 2002 Farm Act have an impact on farmers' acreage decisions. Following the theoretical framework developed by Chavas and Holt, the acreage response model – both the linear acreage and acreage share specifications - under return risk is estimated using seemingly unrelated

regression for major program crops (corn, soybeans, and wheat) in the North Central region (including eight states) during 1991-2001. Truncated means, variances and covariances of per unit crop prices are calculated to reflect government support provided to farmers through marketing loan programs and counter-cyclical payments. The results indicate that the expected net returns variables have, for the most part, a sign consistent with theory. The null hypothesis that coefficients of all risk variables in each acreage equation are jointly zero is rejected in the soybean equation suggesting the importance of risk in farmers' soybean acreage decisions. It is not rejected in the corn and wheat acreage equations. The null hypothesis that all coefficients of the initial wealth variable are jointly zero is rejected, which shows that wealth has an important effect on farmers' acreage decisions. Overall, an increase in initial wealth will lead to an increase in acreage planted to all crops, which implies that farmers exhibit decreasing absolute risk aversion. Using the estimated coefficients in a linear acreage model, the authors simulate the effects of counter-cyclical payments on acreage decisions for 2005 in major field crops in Illinois by comparing two scenarios: market conditions without counter-cyclical payments, and market conditions with counter-cyclical payments. The effect of counter-cyclical payments on acreages appears to be small, with an increase of 80,000 acres for corn and 50,000 acres for wheat while soybean acreage remains unchanged. However, the authors mention that the effects of CCPs may go beyond their short-run effects on farmers' acreage decisions; longer term, there may be structural implications to the extent that these payments keep farmers in business.

Hennessy (1998) develops a theoretical framework to show the production effects of income support programs in stochastic environments. He models a risk-averse farmer, maximizing expected utility from profit. The farmer earns support-adjusted profit which is the summation of stochastic profit from the market and a decoupled payment. The model

decomposes the production impacts of income support programs under uncertainty into wealth, insurance, and coupling effects. Under the conditions that (i) farmer's preferences display decreasing absolute risk aversion, (ii) the risk faced by the farmer reduces his optimal level of the choice variable so that a risk-reducing policy can mitigate the choice variable-depressing impacts of risk, (iii) support-adjusted profit increases with risk and, (iv) the decoupled payment reduces the risk faced by the farmer, the optimal choice of the farmer increases as the magnitude of support increases. The decoupled programs reduce the coefficient of absolute risk aversion by increasing expected profit (wealth effect) as well as reduce the degree of risk faced by farmers by reducing the variability of profit (insurance effect). The author also shows that under constant absolute risk aversion, wealth effects are absent and the optimal choice is only influenced by insurance effects due to the reduced income variability induced by the increase in government supports. A decoupled program must be invariant to the source of uncertainty for the insurance effect to be absent and in this case government support will induce a pure wealth effect. Thus, income support policies that are assumed to be decoupled are not, in fact, decoupled and may affect production decisions. Moreover, in order to obtain some measure of the magnitudes of the wealth and insurance effects of a target price program based on fixed yield (i.e. a decoupled structure), Hennessy conducts empirical simulation for a 400-acre corn farm in Iowa. The results indicate that an increase in the magnitude of support programs could increase input use (nitrogen) by a maximum of 15 per cent (through both wealth and insurance effects), while the increase in production is small with a maximum of 2.75 per cent (through both wealth and insurance effects). By controlling for the wealth effect, it seems that the insurance effects are much larger than wealth effects.

Following Hennessy (1998), Sckokai and Moro (2006) examine the impact of the new

Mid-Term Review single farm payment of the European Union's Common Agricultural Policy (CAP) on acreage decisions by considering both the insurance and wealth effects of policy changes. By assuming that risk arises due to uncertain prices and that farmers display constant relative risk aversion preferences, and by adopting nonlinear mean-variance risk preferences, the dual expected utility function is specified and then output supply, input demand, and land allocation equations are derived (using Hotelling Lemma) as a function of initial wealth, expected output prices, input prices, variance-covariance of prices, and crop-specific area payments, among other variables. The authors use farm level data from the Italian Farm Accounting Data Network to empirically estimate a ten equation system of output supply (corn, durum wheat, other cereals, oilseeds), input demand (seeds and chemicals, and other inputs), and land allocation (land to corn, land to durum wheat, land to other cereals, land to oilseeds) over 1993-1999[1]. As both expected cereal prices and the corresponding elements of the variance-covariance matrix are influenced by the existence of the guaranteed minimum prices for cereals during the period of 1993-1999, the price distribution at the minimum price level is truncated.

The null hypothesis that all variance and covariance coefficients are jointly equal to zero is rejected which implies a rejection of risk neutrality. The parameters estimated over the 1993-1999 period are then used to simulate the effects of the combination of the Agenda 2000 and the 2003 Mid-Term Review (MTR) reforms, through a scenario with a decrease in cereal intervention prices partially compensated by an increase in cereal area payments, which have been transformed, together with oilseed payments, into a single farm payment (SFP). Under this

[1]Since many farms in the sample do not produce some of the crops, the problem of corner solutions for some outputs exists. The fraction of farms not producing ranges from a minimum of 41 per cent to a maximum of 62 per cent for the five outputs. To deal with corner solutions, the authors use the two-step estimation procedure. In the first step, the five probit models (one for each output) are estimated using the level of some quasi-fixed inputs (capital, family labour, and land) and two sets of dummy variables representing geographical location (North, Center, and South) and altitude (mountains, hills, and plains) as explanatory variables. In the second step, the first-stage probit estimates of the corresponding parameters are used in a new form of a system of ten simultaneous equations.

scenario, the insurance effect has been derived by shocking the model with the change in income/wealth variability only, the relative price/payment effect by shocking the model with the changes in prices and payments only, and the wealth effect by shocking the model with the change in wealth (resulting from the discounted value of future payments guaranteed by the MTR reform, SFP) only. The simulation results show that the introduction of the non-stochastic SFP reduces income variability and offsets the impact of the increased price variability due to reduction in the intervention price. While the size of the wealth effect is positive but quite small, the insurance effect may generate up to a 7 per cent increase in acreage, which implies that the size and direction of acreage are strongly influenced by the impact of CAP reforms on farm income/wealth variability.

Coyle, Wei and Rude (2008) study the hypothetical impacts of the Canadian Agricultural Income Stabilization (CAIS) program on crop production under risk aversion and price uncertainty for wheat, barley, canola and other crops (oats, rye, flax) in Manitoba over 1966-2002 (which is prior to CAIS implementation). First, an autoregressive distributed lag (ADL) crop yield model is specified as a function of expected price and price variance[2], initial wealth, mean and variance of weather, and the covariance between government payments and crop market prices (to capture an insurance effect of government payments). Note that since the production homogeneity condition implied by constant relative risk aversion (CRRA) states that output supply is homogeneous of degree zero in expected output price, input price, price variances, and initial wealth, all monetary variables normalized by an input price index and variance-covariance elements are normalized by squared price. Then, a static econometric model of Manitoba crop acreage (share) demands conditional on yields is also estimated as a function

[2]By assuming disjoint technologies (and similar capital/acreage ratios across crops), crop yield can be modelled independently of cross price effects.

of expected revenues and variance-covariance in revenues[3] per acre for own and competing crops, initial wealth, weather variance, and variable input price indexes. Long run impacts on output are the sum of long run impacts on yields plus long run impacts on acres.

The authors develop a simple analytical model of crop production response to CAIS over 1966-2002. It is shown that under CAIS effective prices of outputs and inputs decline because an increase in output and, hence, income implies a reduction in government share of payments. Impacts of CAIS on the normalization (Expected price/w_i, input price/w_i, Variance of price/w_i^2, Wealth/w_i), where w_i is an input price index, consistent with constant relative risk aversion (CRRA) are calculated. It is calculated that CAIS leads to seven percent increases in relative expected effective prices. CAIS leads to the substantial change in effective prices relative to nominal wealth which implies a substantial increase in relative wealth (Wealth/w_i) by 33 percent. Moreover, under CAIS relative price uncertainty is calculated to increase by 14 percent. Using estimated elasticities of the econometric models, calculations show that under CRRA assumption, annual crop production increases by six per cent for wheat, nine per cent for barley, and decreases by one per cent for canola for a hypothetical implementation of CAIS over 1966-2002[4].

I general, the literature clearly shows that support policies that are decoupled in a deterministic world can affect the decisions of the risk averse producers when there is uncertainty. In the next section, we provide a detailed theoretical framework that is able to

[3]By assuming that only prices are stochastic, an adaptive expectation scheme is used to calculate expected prices and variance-covariance elements.

[4]The authors consider the standard program of Gross Revenue Insurance program (GRIP) as a benchmark for the CAIS. After calculating the percentage change in farm level crop output prices due to GRIP (indemnities minus farmer premiums) relative to market prices, and correlations of total indemnities with a Divisia index of market prices for all crops, the econometric models is used to simulate the impacts of the price support and insurance effects of GRIP on output. By comparing the effects of GRIP and CAIS, for wheat and barley, CAIS impacts on long run yields arising from increases in relative effective prices and increases in normalized wealth are less substantial than the simulated impacts for the historical GRIP, which provided large and transparent subsidies to crop prices.

capture the impact of supposedly decoupled support programs on acreage decisions through wealth and insurance effects.

3 The Theoretical Model

3.1 The Model

In this section, we modify Chavas and Holt's (1990) expected utility model for acreage decisions. Consider a farm household producing n crops, agricultural revenue is given by

$$R = \sum_{i=1}^{n} p_i y_i A_i \tag{1}$$

where p_i is the market price of the ith crop, A_i is the number of acres devoted to the ith crop and y_i is the corresponding yield per acre, $i = 1,..., n$. The total cost of agricultural production is

$$C = \sum_{i=1}^{n} c_i A_i \tag{2}$$

where c_i shows the cost of production per acre of the ith crop. In the present case, revenue (R) is a risky variable because output prices $p = (p_1,..., p_n)$ and crop yields $y = (y_1,..., y_n)$ are not observed by the household when production decisions are made. Input prices and per acre costs (c_i), however, are known at the time crop acreages are allocated.

The household faces the budget constraint

$$I + R - C = qG, \qquad or \qquad I + \sum_{i=1}^{n} p_i y_i A_i - \sum_{i=1}^{n} c_i A_i = qG \tag{3}$$

where I denotes exogenous income (initial wealth) and G is an index of household consumption of goods purchased with corresponding consumer price index q, qG presents household consumption expenditures. The above equation states that initial wealth (I) plus farm

profit ($R-C$), which can be called total wealth ($I+R-C=\mathrm{W}$), is equal to consumption expenditures (qG). The constraint on acreage decisions (or adding-up constraint) can be represented by

$$f(A)=0 \tag{4}$$

where $A=(A_1,...,A_n)$.

Assume that the farm household preferences are represented by a von Neumann-Morgenstem (v.N-M) utility function $U(W)$[5] satisfying $U_W>0$. If the farm household maximizes expected utility of normalized total wealth under competition, then the decision model is

$$\begin{aligned} &Max \quad E[U(W)] \\ &s.t. \quad I+\sum_{i=1}^{n} p_i y_i A_i-\sum_{i=1}^{n} c_i A_i=\mathrm{W} \quad and \quad f(A)=0 \end{aligned} \tag{5}$$

where E is the expectation operator over the random variables. After substituting the budget constraint into the utility function, the maximization problem is expressed as

$$\begin{aligned} &Max \quad E[U(I/q+\sum_{i=1}^{n}(p_i/q y_i-c_i/q)A_i)] \quad s.t. \quad f(A)=0, \quad or \\ &Max \quad E[U(w+\sum_{i=1}^{n}\pi_i A_i)] \quad s.t. \quad f(A)=0 \end{aligned} \tag{6}$$

where $w=(I/q)$ is normalized initial wealth and $\pi_i=(p_i/q)y_i-(c_i/q)$ denotes normalized profit per acre of the ith crop, and all prices are deflated by the consumer price q.

In this setting, the acreage decision, A, is made under both price and production uncertainty. Both yields y and output prices p are random variables with given subjective probability distributions. Consequently, the expectation E is over the uncertain variables p and

[5]Note that normalized total wealth is equal to $W=\mathrm{W}/q$, where W is total wealth before normalization.

y and is based on the information available to the household at planting time.

If A^* denotes the optimal acreage choice in optimization equation (6), then the Lagrange's equation will be $L = E[U(w+\Pi A')] + \mu(f(A))$ where $\mu > 0$ and the first-order condition ($\frac{\partial L}{\partial A} = 0$) [6] is written as[7]

$$E[U_W \Pi] + \mu f_A = 0 \tag{7}$$

where $\Pi = (\pi_1,...,\pi_n)$ is assumed to be a random variable with mean $\overline{\Pi}$ and variance-covariance matrix σ, $A' = (A_1,...,A_n)'$ and $f_A = \partial f/\partial A$ is a $(1\times n)$ of vector. We follow Newbery and Stiglitz (1979) and expand U_W around expected wealth W, $\overline{W}' = w + A\overline{\Pi}'$. First-order Taylor series expansion about mean profit yields $U_W \cong \overline{U}_W + A(\Pi' - \overline{\Pi}')\overline{U}_{WW}$, where $\overline{U}_W$ and $\overline{U}_{WW}$ are the first and second-order derivatives of the utility function evaluated at the expected wealth $\overline{W}$. Substituting the Taylor series expansion into the first-order condition (7) and rearranging terms yields[8]:

$$\overline{U}_W \overline{\Pi} + \overline{U}_{WW} A\sigma + \mu f_A = 0 \tag{8}$$

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[6]Note that $\frac{d\Pi A'}{dA} = \Pi$

[7]The second-order condition for the objective function to be maximized is:

$$E[U_{WW}(\Pi)^2] + \mu f_{AA} < 0,$$

since $\mu > 0$, this requires that $U_{WW} < 0$ and $f_{AA} < 0$. $U_{WW} < 0$ implies to the concavity of utility function, and the concavity of the v.N-M utility function provides the fundamental feature of risk aversion.

[8]From (7),

$$E[U_W \Pi] \cong E[(\overline{U}_W + A(\Pi' - \overline{\Pi}')\overline{U}_{WW})\Pi]$$

then,

$$E[U_W \Pi] \cong \overline{U}_W E[\Pi] + \overline{U}_{WW} A[E(\Pi^2) - (E(\Pi))^2]$$

then,

$$E[U_W \Pi] \cong \overline{U}_W \overline{\Pi} + \overline{U}_{WW} A\sigma,$$

note that σ is crop profit variance-covariance matrix with order $n\times n$.

Therefore, optimal acreage choice in (6) depends on normalized initial wealth w, expected normalized crop profits per acre $\bar{\pi}_i = E[(p_i/q)y_i - (c_i/q)]$, as well as second moment. In other words, the optimal acreage decision can be written as $A^*(w;\overline{\Pi};\sigma)$, where $\overline{\Pi} = (\bar{\pi}_1,...,\bar{\pi}_n)$ and σ is crop profit variance-covariance matrix.

3.2 Properties of the Optimal Acreage Decision

In this section we focus on the theoretical restrictions implied by (6) which can modify the empirical specification of the acreage decision $A^*(w;\overline{\Pi};\sigma)$. Through theoretical restriction channel, we contribute to the literature by incorporating the insurance effect (income stabilization) emphasized in the literature, while ignored by Chavas and Holt model (1990), into our theoretical model. In fact, based on the theoretical discussions regarding the role of insurance effect in acreage decisions, we extend the theoretical restrictions examined by Chavas and Holt (1990), which enables us to include this effect in our model specification.

First, by considering the relationship between the wealth compensated and uncompensated acreage decision functions, Chavas and Holt (1990) have shown that the acreage decision is affected by expected total wealth (wealth effect). However, the theoretical framework provided by Hennessy (1998) suggests a role for an insurance effect in acreage decisions. Hence, we should also consider the relationship between income stabilization compensated and uncompensated acreage decision functions. Based on this modification, we will have a specification different from the one by Chavas and Holt (1990), i.e. acreage response would be a function of variance of total profit in addition to the expected total wealth, expected individual crop profits and the variance-covariance of individual crop profits. The procedure that shows total wealth and its variance should be included in the model is as follows.

Consider the compensation function, C, defined implicitly as follows

$$\{V(w+C,.) = \max_{s.t.\, f(A)=0} E[U(w+C+\Pi A')] = U^0\}$$

where V denotes the indirect objective function and C is the certain amount of money that must be given to (or paid by, if negative) the decision maker in order to keep him at a particular level of utility U^0. The compensation function as defined in the above is a function of w, $\overline{\Pi}$, σ and U^0. The relationships between the uncompensated choice function A^* and the compensated function A^c are defined as

$$A^c(w,\overline{\Pi},\sigma,U^0) = A^*(w+C(w,\overline{\Pi},\sigma,U^0),\overline{\Pi},\sigma)$$

The above expression indicates how the compensation, C, influences optimal choices. By differentiating with respect to $\overline{\Pi}$ and σ[9], we have

$$\left(\frac{\partial A^c}{\partial \overline{\Pi}} \quad \frac{\partial A^c}{\partial \sigma}\right)_{n\times n(n+1)} = \left(\frac{\partial A^*}{\partial \overline{\Pi}} \quad \frac{\partial A^*}{\partial \sigma}\right)_{n\times n(n+1)} + \left(\frac{\partial A^*}{\partial C}\right)_{n\times 1} \cdot \left(\frac{\partial C}{\partial \overline{\Pi}} \quad \frac{\partial C}{\partial \sigma}\right)_{1\times n(n+1)} \tag{9}$$

Since Levy and Markowitz (1979) have demonstrated that the mean-variance model is appropriate as a second-order Taylor series approximation to all risk-averse utility functions, in order to determine $\frac{\partial A^c}{\partial \overline{\Pi}}$ and $\frac{\partial A^c}{\partial \sigma}$, for simplicity we can consider the expected utility in the above as $U = \overline{W} - \frac{1}{2}\tau\sigma_W$ where $\overline{W}$ is expected total wealth, τ shows the non-constatnt coefficient of risk aversion, i.e. $\tau(\overline{W},\sigma_W)$, and σ_W is the variance of wealth. We define

[9]Note that Chavas and Holt (1990) consider only the differentiation with respect to $\overline{\Pi}$ and do not consider another element σ in the choice functions.

$\overline{W}^o = w + \overline{\Pi}A'$, where expected total wealth before compensation $\overline{W}^o$ is initial wealth w plus expected income from the market, $\overline{\Pi}A'$, and $\sigma_T^o = A\sigma A'$, where σ_T^o is the variance of total wealth before compensation. If $\overline{W} = \overline{W}^o + C_W$ and $\sigma_T = \sigma_T^o - C_\sigma$ are total wealth and variance after compensation and $C = C_W + C_\sigma$, we can write $U = w + \overline{\Pi}A' - \frac{1}{2}\tau A\sigma A' + C$. Using the envelope theorem, we can write[10],

$$\frac{\partial \overline{W}^o}{\partial \overline{\Pi}} = \frac{\partial U/\partial \overline{\Pi}}{\partial U/\partial \overline{W}^o} = \frac{A^{c'}}{1}$$

$$\frac{\partial \overline{W}^o}{\partial \overline{\Pi}} = A^{c'}$$

and[11]

$$\frac{\partial \sigma_T^o}{\partial \sigma} = \frac{\partial U/\partial \sigma}{\partial U/\partial \sigma_T^o} = \frac{-A'A}{-1}$$

$$\frac{\partial \sigma_T^o}{\partial \sigma} = A^{c'}A^c$$

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[10] Note that $\frac{\partial \overline{W}^o}{\partial \overline{\Pi}} = \frac{\partial U/\partial \overline{\Pi}}{\partial U/\partial \overline{W}^o} = \frac{A^{c'} - A^{c'}\frac{\sigma_T}{2}}{1 - \frac{\sigma_T}{2}} = \frac{A^{c'}(1 - \frac{\sigma_T}{2})}{1(1 - \frac{\sigma_T}{2})}.$

[11] Note that $\frac{\partial \sigma_T^o}{\partial \sigma} = \frac{\partial U/\partial \sigma}{\partial U/\partial \sigma_T^o} = \frac{-\frac{\tau}{2}A'A - \frac{\sigma_T}{2}\frac{\partial \tau}{\partial \sigma_T}A'A}{-\frac{\tau}{2} - \frac{\sigma_T}{2}\frac{\partial \tau}{\partial \sigma_T}} = \frac{(\frac{\tau}{2} + \frac{\sigma_T}{2}\frac{\partial \tau}{\partial \sigma_T})(-A'A)}{(\frac{\tau}{2} + \frac{\sigma_T}{2}\frac{\partial \tau}{\partial \sigma_T})(-1)}.$

where $A'A$ is a $n \times n$ matrix

$$\begin{pmatrix} A_1^2 & A_1A_2 & \cdots & A_1A_n \\ A_2A_1 & A_2^2 & \cdots & A_2A_n \\ \cdots & \cdots & \cdots & \cdots \\ A_nA_1 & A_nA_2 & \cdots & A_n^2 \end{pmatrix}.$$

Now, each element of matrix $\begin{pmatrix} \frac{\partial A^c}{\partial \overline{\Pi}} & \frac{\partial A^c}{\partial \sigma} \end{pmatrix}$ can be written as

$$\frac{\partial A^c}{\partial \overline{\Pi}} = \frac{\partial A^*}{\partial \overline{\Pi}} + \frac{\partial A^*}{\partial C}\frac{\partial C}{\partial \overline{\Pi}}$$

where $\frac{\partial A^*}{\partial C} = \frac{\partial A^*}{\partial \overline{W}}\frac{\partial \overline{W}}{\partial C}$ and since $\frac{\partial \overline{W}}{\partial C} = 1$, therefore $\frac{\partial A^*}{\partial C} = \frac{\partial A^*}{\partial \overline{W}}$. Moreover, $\frac{\partial C}{\partial \overline{\Pi}} = \frac{\partial C}{\partial \overline{W}^o}\frac{\partial \overline{W}^o}{\partial \overline{\Pi}}$ and since $\frac{\partial C}{\partial \overline{W}^0} = -1$, $\frac{\partial \overline{W}^o}{\partial \overline{\Pi}} = A^{c'}$ and replacing $\frac{\partial \overline{W}^o}{\partial \Pi} = A^{c'}$ by $A^{*'}$ at $C = 0$, therefore $\frac{\partial C}{\partial \overline{\Pi}} = -A^{*'}$. Thus, we have,

$$\frac{\partial A^c}{\partial \overline{\Pi}} = \frac{\partial A^*}{\partial \overline{\Pi}} - \frac{\partial A^*}{\partial \overline{W}}A^{*'} \qquad (10)$$

The matrix of compensated effects $\frac{\partial A^c}{\partial \overline{\Pi}}$ in expression (10) is symmetric, positive semidefinite (Chavas, 1987). Expression (10) also indicates that the slope of the uncompensated function $\frac{\partial A^*}{\partial \overline{\Pi}}$ can be decomposed as the sum of two terms: the compensated slope (or substitution effect) $\frac{\partial A^c}{\partial \overline{\Pi}}$ which maintains a given level of utility plus the wealth effect ($\frac{\partial A^*}{\partial \overline{W}}A^{*'}$).

This wealth effect shows the income-supporting attribute of government policies, that is, higher average income arising from the support policy may affect producer decisions. These results are quite general since equation (10) holds for any risk preferences[12].

Further,

$$\frac{\partial A^c}{\partial \sigma} = \frac{\partial A^*}{\partial \sigma} + \frac{\partial A^*}{\partial C}\frac{\partial C}{\partial \sigma}$$

where $\frac{\partial A^*}{\partial C} = \frac{\partial A^*}{\partial \sigma_T}\frac{\partial \sigma_T}{\partial C}$ and since $\frac{\partial \sigma_T}{\partial C} = -1$, therefore $\frac{\partial A^*}{\partial C} = \frac{\partial A^*}{\partial \sigma_T}$. Also, $\frac{\partial C}{\partial \sigma} = \frac{\partial C}{\partial \sigma_T^o}\frac{\partial \sigma_T^o}{\partial \sigma}$ and since $\frac{\partial C}{\partial \sigma_T^o} = 1$, $\frac{\partial \sigma_T^o}{\partial \sigma} = A^{c'}A^c$ and replacing $\frac{\partial \sigma_T^o}{\partial \sigma} = A^{c'}A^c$ by $A^{*'}A^*$ at $C = 0$, therefore $\frac{\partial C}{\partial \sigma} = A^{*'}A^*$. Thus, we have,

$$\frac{\partial A^c}{\partial \sigma} = \frac{\partial A^*}{\partial \sigma} - \frac{\partial A^*}{\partial \sigma_T}A^{*'}A^* \qquad (11)$$

Expression (11) indicates that the slope of the uncompensated function $\frac{\partial A^*}{\partial \sigma}$ can be decomposed as the sum of two terms: the compensated slope, $\frac{\partial A^c}{\partial \sigma}$, which maintains a given

[12]Under constant absolute risk aversion, the wealth effect vanishes implying that $\partial A^c/\partial \overline{\Pi} = \partial A^*/\partial \overline{\Pi}$. In this case, compensated and uncompensated choice functions have the same slope with respect to $\overline{\Pi}$ and $\partial A^*/\partial \overline{\Pi}$ is a symmetric, positive semidefinite matrix from (10). This illustrates the influence of risk preferences on acreage choice functions since nonzero wealth effects reflect nonconstant absolute risk aversion. Also, note from (10) that non-negative wealth effects ($\partial A^*/\partial W \geq 0$) are sufficient conditions to guarantee that an increase in expected returns per acre of the ith crop will result in an increase in the optimal acreage of that crop i.e., $\partial A_i^*/\partial \overline{\pi}_i \geq 0$.

level of utility plus the insurance effect, $\frac{\partial A^*}{\partial \sigma_T} A^{*'} A^*$, emphasized in the literature (Hennessy, 1998) but ignored by Chavas and Holt (1990). This insurance effect shows the income-stabilizing attribute of government policies; that is, programs may affect optimal decisions by reducing the variance of the farm crop portfolio directly.

Second, another theoretical restriction is a homogeneity condition which has been derived by Chavas and Pope (1985) in the context of the expected utility model (6). In particular, rewriting expression (4) as $f(A) = A_1 - g(A_{\cdot}) = 0$, where $A = (A_1, A_{\cdot})$, Chavas and Pope have shown that the following restriction holds at the optimum under any risk preferences

$$\frac{\partial A^*}{\partial \overline{\Pi}} \left(\frac{\partial f(A)}{\partial A}\right) - \frac{\partial A^*}{\partial w} \cdot \frac{\partial f(A)}{\partial A} \cdot A = 0 \tag{12}$$

Consider the first-order conditions (7), we have $f_A = E[U_W \Pi]/\mu$ and we know that $E[U_W \Pi] = Cov(U_W, \Pi) + E(U_W)E(\Pi)$. Given $\mu \neq 0$, substituting these conditions into (12) yields

$$\frac{\partial A^*}{\partial \overline{\Pi}} (\overline{\Pi} + \varphi) - \frac{\partial A^*}{\partial w} (\overline{\Pi}' + \varphi') A = 0 \tag{13}$$

where $\varphi = Cov(U_W, \Pi)/E(U_W)$ is an $(n \times 1)$ vector.

Under risk neutrality, $\partial A^*/\partial w = 0$ and $\varphi = 0$, implying from (13) that the acreage decision function A^* is homogenous of degree zero in $\overline{\pi}_j$ (or in output and input prices, p and c), $\sum_{j=1}^{n} \frac{\partial A_i^*}{\partial \overline{\pi}_j} \overline{\pi}_j = 0$. This homogeneity restriction of classical production theory states that production decisions are not affected by proportional changes in all input and output prices. However, under risk aversion, $\varphi \neq 0$ and (13) implies that this homogeneity-like restriction takes

a different form. In other words, in general under uncertainty the classical result of riskless production theory, which asserts that production decisions depend only on input-output price ratios, does not hold. Pope (1988) has presented some empirical implications of specific forms of risk preferences. In particular, under constant relative risk aversion[13], a positive scaling of wealth does not alter optimal decisions (Sandmo, 1971)[14]. This implies that decision functions are almost homogenous of degree one in initial wealth, degree one in mean returns $\overline{\Pi}$, degree two in moments of order two, and degree s in moments of order s of π (See Pope, 1988 for details).

3.3 Model Specification

As explained in section 3.1, the optimal acreage decision can be written as $A^*(w, \overline{\Pi}, \sigma)$. Note that the government payments' influence on the subjective probability distribution of profits is modeled by by truncating the distribution. The resulting truncation of the subjective probability distribution of profits will affect expected profits, $\overline{\Pi}$, as well as the second moment of the profit distribution σ. Thus, we incorporate government programs into the acreage decision model using a truncation method (see Appendix C for details).

Using the first-order Taylor series expansion, the acreage equations can be specified as

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[13]The coefficient of relative risk aversion is defined as

$$\tau = (w + \sum_{i=1}^{n} \pi_i A_i)(-\frac{U_{ww}}{U_w})$$

where $(-\frac{U_{ww}}{U_w})$ is the coefficient of absolute risk aversion.

[14]According to Pope (1988), a function $h(Z_1,...,Z_N)$, $h: R^N \to R$ is said to be almost homogenous of degree $C_1,...,C_N$ and zero respectively if $h(\lambda^{C_1} Z_1,...,\lambda^{C_N} Z_N) = \lambda^0 h(Z_1,...,Z_N)$ where $\lambda \in R^+$, the positive real line.

$$A_{it} = a_0 + (\partial A_i/\partial w)w_{t-1} + \sum_{j=1}^{n}(\partial A_i/\partial \overline{\pi}_j)\overline{\pi}_{jt}^{T} + \sum_{k\geq j}^{n}\sum_{j=1}^{n}(\partial A_i/\partial \sigma_{jk})\sigma_{jkt}^{T} + \upsilon_{it} \quad (14)$$

where $\overline{\pi}^{T}$ is the truncated mean of crop profits and σ^{T} shows the truncated variance-covariance of crop profits. Using (10) and (11), it follows that equation (14) can be expressed alternatively as

$$\begin{aligned} A_{it} \quad &= a_0 + (\partial A_i/\partial w)w_{t-1} + \sum_{j=1}^{n}(\partial A_i^c/\partial \overline{\pi}_j + \partial A_i/\partial \overline{W}A_j)\overline{\pi}_{jt}^{T} + \\ &\sum_{k\geq j}^{n}\sum_{j=1}^{n}(\partial A_i^c/\partial \sigma_{jk} + \partial A_i/\partial \sigma_T A_j A_k)\sigma_{jkt}^{T} + \upsilon_{it} \end{aligned} \quad (15)$$

Note that σ_T denotes the variance of total (farm) profit and σ^{T} shows the truncated variance of crop profit. Letting $\beta_{ij} = \partial A_i^c/\partial \overline{\pi}_j$ and $\gamma_{ijk} = \partial A_i^c/\partial \sigma_{jk}$ be the compensated slopes with respect to $\overline{\pi}$ and σ, respectively, then

$$A_{it} = a_0 + \alpha_i(w_{t-1} + \sum_{j=1}^{n}A_j\overline{\pi}_{jt}^{T}) + \sum_{j=1}^{n}\beta_{ij}\overline{\pi}_{jt}^{T} + \sum_{k\geq j}^{n}\sum_{j=1}^{n}\gamma_{ijk}\sigma_{jkt}^{T} + \delta_i(\sum_{k\geq j}^{n}\sum_{j=1}^{n}A_j A_k\sigma_{jkt}^{T}) + \upsilon_{it} \quad (16)$$

where $\alpha_i = \partial A_i/\partial \overline{W}$ [15] and $\delta_i = \partial A_i/\partial \sigma_T$. Note that in equation (16), $\sum_{j=1}^{n}A_j\overline{\pi}_{jt}^{T}$ is equal to the truncated mean of total (farm) profit (along with initial wealth comprises the wealth effect) and $\sum_{k\geq j}^{n}\sum_{j=1}^{n}A_j A_k\sigma_{jkt}^{T}$ is equal to the truncated variance of total (farm) profit (i.e. the insurance effect). In the absence of a priori information about functional form, equation (16) provides a local approximation to the decision function $A^{*}(.)$. Also, the symmetry of (10) implies that $\beta_{ij} = \beta_{ji}$, $i \neq j$. Equation (16) can be used directly for an empirical analysis of acreage decisions.

[15] Note that $\partial A_i/\partial w = \partial A_i/\partial \overline{W}.\partial \overline{W}/\partial w$ and since $\partial \overline{W}/\partial w = 1$ (because $\overline{W} = w + \overline{\Pi}A'$), therefore $\partial A_i/\partial w = \partial A_i/\partial \overline{W}$.

Regrading the expected sign of the variables in equation (16), it is shown that the expected own-profit and its variance should have positive and negative impacts on acreage in each equation, respectively. The effect of expected cross-profits and other elements of the covariance matrix on acreage decisions are not known *a priori* (See Appendix D for details). Although it is presumed that the expected total wealth (wealth effect) and its variance (insurance effect) have positive and negative impacts on acreage allocations with no constraint on total acreage, the sign of these variables are not clear *a priori* when the total acreage is assumed to be fixed. In this case, the different signs across equations suggest that producers will shift from less risky crops to more risky crops as a result of the wealth and insurance effects.

In sum, the theoretical framework shows that acreage allocated to each crop can be specified as a function of the expected profits from each individual crop, elements of the profit variance-covariance matrix, as well as expected total wealth and its variance. The latters capture the wealth and insurance effects of support programs. In the next section, we apply our theoretical model to measure the effect of government crop programs on acreage decisions for major farm crops in the prairie provinces of Canada.

4 The Empirical Framework

The empirical estimation in this paper utilizes provincial-level data to determine supply responses for spring wheat, durum wheat, oats, barley, rye, peas, flax, canola, and hay in the prairie provinces of Canada. Farmers' acreage decisions are estimated by pooling time-series (1971-2006) with cross section (individual provinces, Manitoba, Saskatchewan and Alberta) data. Two specifications of the acreage response model are examined in this study: acreage level model and acreage share model. The share equations are specified to explain how the shares of

total cropland allocated to specific crops respond to the expected profits, profit risks, total wealth, and other exogenous variables. The specification explicitly recognizes that as the share of the combined cropland planted to one commodity (say wheat) increases, the expanded wheat acreage has to come from cropland planted to competing crops, such as barley, canola, or other field crops. In other words, the sum of the acreage shares equals one (total cropland planted to all field crops is assumed to be fixed). The empirical model treats all equations as a system of acreage allocation decisions under risk. The linear acreage and acreage-share models (with acreage share (S_i) of the crops in each province as the dependent variable) have the following structure:

$$A_{it} = a_0 + \alpha_i(w_{t-1} + \sum_{j=1}^{9} A_j \bar{\pi}_{jt}^T) + \sum_{j=1}^{9} \beta_{ij} \bar{\pi}_{jt}^T + \sum_{k \geq j}^{9} \sum_{j=1}^{9} \gamma_{ijk} \sigma_{jkt}^T + \delta_i (\sum_{k \geq j}^{9} \sum_{j=1}^{9} A_j A_k \sigma_{jkt}^T) + \varphi_l + A_{it-1} + \upsilon_{it} \quad (29)$$

$$S_{it} = a_0 + \alpha_i(w_{t-1} + \sum_{j=1}^{9} A_j \bar{\pi}_{jt}^T) + \sum_{j=1}^{9} \beta_{ij} \bar{\pi}_{jt}^T + \sum_{k \geq j}^{9} \sum_{j=1}^{9} \gamma_{ijk} \sigma_{jkt}^T + \delta_i (\sum_{k \geq j}^{9} \sum_{j=1}^{9} A_j A_k \sigma_{jkt}^T) + \varphi_l + S_{it-1} + \upsilon_{it} \quad and \quad \sum_{i=1}^{10} S_i = 1 \quad (30)$$

where A_i is the acreage planted to the ith crop (1 = spring wheat, 2 = durum wheat, 3 = oats, 4= barley, 5= rye, 6= peas, 7= flax, 8= canola, and 9= hay; in acres), S_i is the share of combined acreage of spring wheat, durum wheat, oats, barley, rye, peas, flax, canola, hay planted to the ith crop (1 = spring wheat, 2 = durum wheat, 3 = oats, 4= barley, 5= rye, 6= peas, 7= flax, 8= canola, 9= hay, and 10= summerfallow), w is normalized initial wealth ($), $\sum_{j=1}^{n} A_j \bar{\pi}_{jt}^T$ is the truncated mean of total (farm) profit ($) and $\sum_{k \geq j}^{n} \sum_{j=1}^{n} A_j A_k \sigma_{jkt}^T$ is equal to the truncated

variance of total (farm) profit (\$), $\bar{\pi}_j^T$ is the truncated expected profits (\$/acre) for jth commodity, σ_{jk}^T is the truncated expected variance-covariance of profits (\$/acre) between jth and kth commodities, φ_l is provincial dummies ($l = 1,2,3$) or fixed effects to control for persistent provincial factors. A_{it-1} (or S_{it-1}) is a lagged dependent variable for ith commodity and has been included to account for inertia, which is attributable to the cost of adjustment associated with switching from one crop to another[16], and υ_i is the error term.

4.1 Data Description

Assuming that aggregate behavior can be approximated by a representative farm household making decisions according to the theoretical model described, we propose to estimate the linear acreage equations (29) and acreage share equations (30) from aggregate data.

The acreage variables $A_1, A_2, \ldots, A_9$ (1= spring wheat, 2= durum wheat, 3= oats, 4= barley, 5= rye 6= peas, 7= flax, 8= canola, 9=tame hay) measure acreage planted to each crop (in acres) and were obtained from CANSIM table 001-0010 which provides time series data on seeded area by crops at the provincial level. Yields $y_1, y_2, \ldots, y_9$ (tonne/acre) were also obtained from CANSIM table 001-0010. The market prices ($p_1, p_2, \ldots, p_9$) are average farm prices (\$/tonne) and were obtained from the Manitoba Agriculture Yearbook (various years), Manitoba Agriculture, Food and Rural Initiatives; the Agriculture Statistics Yearbook (various years), Alberta Agriculture and Rural Development; and Agricultural Statistics (various years), Saskatchewan Agriculture, Food and Rural Revitalization[17].

[16]This could, to some degree, also reflect the effect of change in crop rotation practices on a specific rotation crop.

[17]Data on durum wheat prices were not available in Manitoba and Alberta. As an alternative, we calculated the durum wheat to spring wheat price ratio in Saskatchewan. Then, we constructed durum wheat prices based on the

Initial wealth is defined as the sum of value of capital stock in crop production (machinery and equipment plus land and buildings) minus related debts. Data on value of machinery and equipment and value of land and buildings from CANSIM table 002-007 and outstanding farm debt from CANSIM table 002-0008 indicates that the value of land and buildings greatly exceeds the other two series, and the other two series largely cancel out. For example, in 2006 the value of land and buildings was $ million 10795, 23156 and 45968, the value of machinery and equipment was $ million 3594, 8129 and 9059 and total debt was $ million 5805, 7024 and 10996 in Manitoba, Saskatchewan and Alberta, respectively. Therefore, initial wealth (in $) is constructed as the value of land and buildings in crop agriculture. This is calculated from total crop acres (CANSIM table 001-0010) multiply by the value per acre of farmland and buildings from CANSIM table 002-003 in Manitoba, Saskatchewan and Alberta for different years.

In Manitoba, all items of costs of crop production[18], in detail, for different crops $c_1, c_2, \ldots, c_9$ ($/acre) were obtained in a request from Manitoba Agriculture, Food and Rural Initiatives, Policy Analysis Branch, Crop Production Costs Guidelines (various publications) for years 1982-2006. For years prior to 1982, we calculated the farm input price index[19] in each year relative to the 1982 farm input price index ratio. Crop costs were constructed based on the multiplication of this ratio by crop costs in 1982. In Saskatchewan, detailed crop costs were obtained in a request from Saskatchewan Agriculture, Food and Rural Revitalization,

multiplication of this ratio by spring wheat prices in Manitoba and Alberta.

[18]It should be noted that we subtracted non-allowable costs like rent (land, building and machinery), building/ machinery repairs, and property tax from the respective calculated costs.

[19]The farm input price indices (index, 1986=100) were obtained from CANSIM table 328-0001. This table provides a price index for all components of farm inputs at the provincial level for different years.

Agriculture, Business and Development Branch, Crop Planning Guide (various publications)[20], for years 1985-2006[21]. We used the same procedure as we did for Manitoba when constructing the crop costs in missing years. In Alberta, detailed crop costs were obtained in a request from Alberta Agriculture and Rural Development, Crops Economics Units for years 1985-2006. For years prior to 1985, crop costs were constructed based on the same method as we used for Manitoba.

To measure yield expectations, actual yields are regressed on a trend variable. The resulting predictions are taken as expected yield as well as from the adaptive expectation procedure provided in equation (33). For expected farm price, an adaptive expectation scheme built from lagged farm prices as shown in equation (32) was used, but in addition the empirical model in this study is forward-looking in that farmers are also assumed to base their expectations on futures prices.

The planting-time crop futures price forecast was taken as the price of December crop futures at planting time from 1982 to 2006[22]. In the cases of spring wheat, oats, barley, flax and canola, the futures price were the price of December crop futures on or about April 30th[23], and are collected from the Canadian grain Industry Statistical Handbook (various issues) and the Winnipeg Commodity Exchange, Statistical Annual (various issues). Since there was no future market for durum wheat, rye, peas and hay, the expected price for these crops were constructed

[20]Crop production costs are reported in different soil zones, black, brown, and dark brown. Since the crop cost data in other provinces were available in only for the black soil zone, we used the black soil zone crop costs in Saskatchewan.

[21]Tame hay production costs were not available in Crop Planning Guide. We obtained hay production cost in 2006 from the publication Dryland Forage Production Costs, Fact Sheet Saskatchewan Ministry of Agriculture, October 2007. Then, we calculated Saskatchewan hay cost to Manitoba hay cost ratio in 2006. We constructed a time series of Saskatchewan hay production costs based on the multiplication of this ratio by hay production cost in Manitoba for different years.

[22]There was no data available on future prices for all crops before 1982.

[23]Note that when data for December futures price were not available, we have used the November or October futures price.

based on the futures price of the commodity that have the highest correlation with these crops[24]. To allow for price differentials across provinces, the futures prices were proportionally adjusted by provincial farm prices[25].

By assuming that both price (p_i) and yield per acre (y_i) are random variables (to reflect not only price risk, but also production risk facing producers) and costs of production for the ith crop (c_i) are constant, we derive the untruncated expected profit for ith crop, the variance of profit and the covariance between crop profits in Appendix B. Appendix C provides the truncated mean, variance and covariance. Since truncation requires a guaranteed point, we explain our method of data construction for guaranteed profit by crop-specific and whole-farm programs in what follows (See Appendix A for a brief history of Canadian agricultural stabilization and support programs).

Crop-Specific Programs

Guaranteed Profit by Agricultural Stabilization Act (ASA)

The ASA provided payments to producers in every province during periods of low commodity prices. It guaranteed farmers 90 percent of a three-year moving-average price (Schmitz, Furtan and Baylis; 2002). Mandatory support was provided for cattle, hogs, lambs and wool; industrial milk and industrial cream; corn and soybeans; and spring wheat, winter wheat,

[24]For example, hay farm prices were regressed on future prices of spring wheat, oats, barley, flax and canola. The highest explanatory power was obtained from barley futures price, which had an R-squared equal to 0.80. Next, we constructed hay futures price by multiplying hay farm price by the ratio of barley futures price over its farm price. For the case of durum wheat, peas and rye, the highest explanatory power was obtained from spring wheat, canola and spring wheat with R-squared 0.98, 0.70 and 0.98, respectively.

[25]In each province, we calculated the difference between obtained futures price from the Winnipeg Commodity Exchange and farm prices and then the province that had the least difference in average (the base province), has been given the collected futures prices. Next, we constructed futures prices for the other provinces by multiplying the farm prices in the province by the ratio of futures prices over farm prices in the base province.

oats and barley (Statistics Canada, 2007). Among the crops in our study, we calculated the support price in each year (from 1970 to 1984) for spring wheat, oats and barley based on the previous three-year average prices ($/tonne). We constructed the guaranteed (gross) profit based on the multiplication of each year's yield (tonne/acre) by 90 percent of support price for spring wheat, oats and barley in each province over 1970-1984. Then, we obtained the guaranteed profit ($/acre) by subtracting the crop production costs from guaranteed gross profit.

Guaranteed Profit by Crop Insurance

The payment mechanism in a Crop Insurance program is based on individual yield coverage which means that a producer can get yield insurance up to a proportion, usually 70 percent or 80 percent, of his or her own ten-year average yield (Schmitz, Furtan and Baylis; 2002). It should be noted that all crop insurance contracts guarantee a price. In each year, we calculated yield guarantee (tonne/acre) as the previous ten-year average yield (y) for each crop in each province multiplied by 0.7. Price coverage ($/tonne) for each crop has been obtained by request from Saskatchewan Crop Insurance Corporation (SCIC); Manitoba Crop Insurance Corporation (MCIC); and Agriculture Financial Services Corporation (AFSC), Alberta; for the years 1970-2006. We constructed the guaranteed (gross) profit based on the multiplication of yield guarantee by price coverage for each crop in each province over 1970-2006. Then, we obtained the guaranteed profit ($/acre) by subtracting the crop production costs from guaranteed gross profit.

Guaranteed Profit by the Gross Revenue Insurance Program (GRIP)

In GRIP, farmers were guaranteed a per-acre return on whatever crop they grew. The program guaranteed producers their long-term average yield. The guaranteed price was set by an

indexed moving average price (Schmitz, Furtan and Baylis; 2002). In each year (from 1991 to 1995), we calculated the previous fifteen-year average yield (tonne/acre) for each crop in each province as the long-term average yield. Price coverage ($/tonne) for each crop has been obtained by request from SCIC, MCIC, and AFSC for the years 1991-1995.We constructed the guaranteed profit ($/acre) based on the multiplication of the long-term average yield by price coverage (minus crop costs) for each crop in each province over 1991-1995.

Whole-Farm Programs

Guaranteed Profit by the Western Grain Stabilization Act (WGSA)

In WGSA[26], payments are based on producers' eligible grain sales. Payment made when aggregate net cash flow (cash receipts minus cash variable costs) from eligible grain (wheat, oats, barley, rye, flaxseed, canola and mustard seed; from 1988 nine crops are added to the seven previously covered – triticale, mixed grains, sunflower, safflower, buckwheat, peas, lentils, fababeans, canary seed) sales was less than the average net cash flow over the previous five years (Schmitz, Furtan and Baylis; 2002). We derived a net cash flow ($) for 1978-1979 and 1984-1991 as total crop receipts ($\sum_{i=1}^{8} p_i y_i A_i$) minus total crop production allowable[27] costs ($\sum_{i=1}^{8} c_i A_i$) in each province. We calculated a previous five-year average net cash flow. The eligible net cash flow in each province was constructed based on the multiplication of the previous five-year average net cash flow by the eligibility ratio[28], which reduces net cash receipts

[26] WGSA was a crop-specific program. But since it covers all crops in our study, we categorized it into whole-farm programs.

[27] We have subtracted property tax, rent, machinery and building repairs, custom work, and stabilization premiums from total crop production costs.

[28] Statistics Canada, percentage distribution of farms by total gross farm receipts class, Census of Agriculture

for those receipts that are not eligible (corporations and production in excess of individual farm limits - $60,000 total receipts per farm). In each province, we used this eligible net cash flow as the guaranteed total profit ($) by WGSA for 1978-1979 and 1984-1991.

Guaranteed Profit by the Net Income Stabilization Account (NISA)

NISA pay-outs were made when the farmer's net income fell below 70 percent of the previous three-year average (Schmitz, Furtan and Baylis; 2002). We derived net farm income ($) for 1991-2002 as total crop receipts ($\sum_{i=1}^{8} p_i y_i A_i$) minus total crop production allowable costs ($\sum_{i=1}^{8} c_i A_i$) in each province. We calculated previous three-year average net cash flow. In each province, we used 70 percent of this net farm income as the total profit ($) guaranteed by NISA over 1991-2002.

Guaranteed Profit by Agricultural Income Disaster Assistance (AIDA)/Canadian Farm Income Plan (CFIP)

In AIDA/CFIP, when producers' net income fell below 70 percent of their three-year, moving average net income they become eligible for a pay-out (Schmitz, Furtan and Baylis; 2002). So we used the same procedure as NISA for constructing the guaranteed total profit ($) over 1998-2002.

Guaranteed Profit by the Canadian Agricultural Income Stabilization (CAIS)

Payments are made when the program year margin falls below the reference year margin. Reference margin is the *Olympic* average of the last five years' production margins, with highest

(various publications).

and lowest years dropped (CAIS handbook, AAFC). We derived net margin ($) for 2003-2006 as total crop allowable receipts ($\sum_{i=1}^{8} p_i y_i A_i$) minus total crop production allowable costs ($\sum_{i=1}^{8} c_i A_i$) in each province[29]. In each year, we dropped the highest and lowest previous five-year margins and then calculated a three-year average margin as the total profit ($) guaranteed by CAIS in each province over 2003-2006.

4.2 Estimation and Results

As indicated earlier, the acreage response model examines farmers' planting decisions for spring wheat, durum wheat, oats, barley, rye, peas, flax, canola, hay and summerfallow in three prairie provinces. To have the most consistent estimation results, we estimate the model with different specifications and different data sets using seemingly unrelated regressions (SUR). We specify the acreage equations in both acres level and share (equations 29 and 30). Moreover, each of these equations is estimated using two sets of data: one contains adaptive expectations for the expected prices and yields, the other one uses the future prices as the expected prices and trend yield as the expected yield. Then, among the different estimations, we choose the model where its results are more consistent with theoretical expectations and which has a higher R-square or lower MSE (Mean Square Error).

To have reliable and theoretically consistent estimations, three restrictions are imposed (these restrictions are the same as what apply to the AIDS demand system across expenditure share equations) that are implied by the theory. As inferred by expression (10), symmetry restrictions require that individual crop cross-profit regression coefficients across the acreage equations be equal; that is,

[29]To be allowable, income and expenses must be directly related to the primary production of agricultural commodities. The CAIS Handbook provides some examples of allowable and non-allowable income and expense items. For instance, crop insurance proceeds are considered as allowable income.

$$\beta_{12} = \beta_{21}, \beta_{13} = \beta_{31}, ..., \beta_{19} = \beta_{91}, \beta_{23} = \beta_{32}, ..., \beta_{29} = \beta_{92}, \beta_{34} = \beta_{43}, ..., \beta_{39} = \beta_{93}, \beta_{45} = \beta_{54}, ...,$$
$$\beta_{49} = \beta_{94}, \beta_{56} = \beta_{65}, ..., \beta_{59} = \beta_{95}, \beta_{67} = \beta_{76}, ..., \beta_{69} = \beta_{96}, \beta_{78} = \beta_{87}, \beta_{79} = \beta_{97}, \beta_{89} = \beta_{98} \quad ,$$

thirty-six constraints. As discussed in the theoretical framework, the acreage decision functions are almost homogenous of degree one in initial wealth, degree one in mean returns, and degree two in moments of order two. This means that if expected wealth and expected crop profits are multiplied by λ and elements of the variance –covariance matrix and variance of total wealth are multiplied by λ^2, the acreage decisions would not change. If the acreage equations are estimated in logarithm form, we can impose the homogeneity restriction on coefficients in each equation (sum of the total wealth and individual crop profits coefficients plus the crop variance-covariance and the variance of total wealth coefficients is equal to zero). However, we are not able to estimate equations in logarithm form because the covariance variables may be negative in the observations. Therefore, we are only able to test for the homogeneity restriction using the estimated coefficients and the mean of the variables. To maintain adding-up restrictions (the sum of the shares for these ten category crops equals one or total cropland is assumed to be fixed over time), we drop one crop acreage equation, summerfallow[30]. In fact, the share (acre level) for summerfallow is treated as a residual, which is not directly estimated to avoid singularity in the disturbance covariance matrix.

The estimation of aggregate acreage response equations involves the use of cross section (three provinces) data. Hence, it is important to control for persistent provincial economic (dis)advantages, including institutional differences and economic conditions. To solve this problem, fixed effects of individual provinces are used in the model, thus we can be more confident that our independent variables coefficients reflect their marginal impacts rather than

[30]Theoretically, this can be done when all regressors are identical across equations. Considering that summerfallow acreage is affected by the same factors as other crops (Clark and Klein), this condition holds in our system.

long-term structural effects related to economic endowments.

After estimation of the four potential models (each of the acreage level and share equations with the adaptive expectations and the futures price-trend yield)[31], results from the acreage level model based on the futures price-trend yield are regarded as the base model due to their consistency with theoretical expectations, more statistically significant coefficients and lower mean square errors[32]. According to the results of the base model, we should not worry about the heteroskedasticity problem that potentially arises from the use of cross section data. The system of acreage equations is estimated by seemingly unrelated regression (SUR), which estimates the equations initially by least square and then incorporates the estimated variance and covariance matrix of residuals in the estimation of generalized least square (GLS). Moreover, we have conducted a heteroskedasticity test in individual equations. According to the Breusch-Pagan test, the null hypothesis of homoskedasticity is not rejected for all crops except peas. P-values of computed Lagrange Multiplier (LM) statistics in spring wheat, durum wheat, oats, barley, rye, flax, canola, and hay equations are 0.5136, 0.4426, 0.5316, 0.3189, 0.6877, 0.1468, 0.9095, and 0.1427, respectively. Hence, the null hypothesis of homoskedasticity cannot be rejected. In the peas equation, the LM test (with p-values 0.0996) is inconclusive, as it depends on the confidence level chosen from chi-squared table. Also, based on the estimated coefficients and mean of variables, we did the test for homogeneity condition. The result indicated that in most equations (except for spring wheat, peas and rye) homogeneity condition cannot be rejected[33].

[31]To increase degrees of freedom and avoid the high collinearity between covariance terms, we omitted insignificant covariance terms in each equation. Although the adding-up restrictions require that all regressors are identical across equations, omitting insignificant covariance terms maybe reasonable considering that there are many regressors that suffer from high degree of collinearity.

[32]Due to the space limitations, only the results from the base model (acreage level model based on the futures prices-trend yield) are presented.

[33]P-valus for the null hypothesis of homogeneity condition for the spring wheat, durum wheat, oats, barley, rye, peas, flax, canola and hay equation are 0.02, 0.79, 0.32, 0.35, 0.06, 0.00, 0.30, 0.13, 0.15, respectively.

The results of the acreage response model incorporating wealth and insurance effects are given in Tables E1 and E2 in Appendix E. The overall fit of the resulting model is good, as indicated by the high R-squared. In addition, the signs on the various variables are generally consistent with theory. As anticipated, expected own profits in spring wheat, oats, peas, flax, canola and hay equations have the expected positive signs and are statistically significant except for peas. As Table 1 shows the acreage elasticity with respect to expected own-profit for these crops are 0.19, 0.21, 0.007, 0.57, 0.38 and 0.03, respectively. Durum wheat, barley and rye do not have the expected signs for expected own profits, but they are insignificant. Although the variance of own profit variables have all the expected negative signs (except for rye with positive sign but insignificant), few of them for barley, flax and hay are statistically significant. As the variance of own profit elasticities in Table 1 show, elasticities are -0.02 for barley, -0.15 for flax and -0.04 for hay.

The results in this study suggest that the effects of risk (variance and covariance variables) on acreage response for major crops are not strong but vary across commodities. In the spring wheat, durum wheat, oats, barley, rye, peas, flax, canola, and hay equations approximately 65, 16, 12, 18, 15, 28, 64, 87, and 30 percent of risk variables respectively are statistically significant. In a multi-output framework, one has to judge the impact of risk on output as the impact of the variance-covariance matrix as a whole. A Wald test to see if beta coefficients of all risk variables in each equation are jointly statistically significant suggests that risk does matter in farmers' spring wheat, oats, rye, peas, flax, canola, and hay planting decisions[34]. However, in the cases of durum wheat and barley, the p-values are 0.26 for the former and 0.34 for the latter. Furthermore, the null hypothesis that beta coefficients of all risk variables in the system of nine

[34]The null hypothesis that beta coefficients of all risk variables are zero in the spring wheat, oats, rye, peas, flax, canola, and hay acreage equations have p-values as follows: 0.00, 0.00, 0.09, 0.03, 0.02, 0.00, and 0.00 respectively.

equations are jointly zero is strongly rejected.

The expected total wealth (initial wealth plus market return) variable is statistically significant in spring wheat, rye and barley equations (as can be seen in Table 1, acreage elasticity with respect to the expected total wealth are 0.16 in spring wheat, 1.22 in rye and 0.16 in barley). However, all beta coefficients of the wealth variable in the system are jointly statistically significant with p-values of 0.002. This means that the wealth is one of the factors that significantly affects the allocation of acres among different crops. The weighted average of wealth variables for individual crops, is estimated to be 0.022[35]. A positive overall wealth effect is consistent with decreasing absolute risk aversion (DARA) preferences[36]. In other words, an increase in wealth leads to a decline in profit risk (including both yield and price risks) aversion and an increase in the acreage planted to more risky crops (note that the total acreage is constant). Regarding the insurance effect, although the insurance variable is only statistically significant in spring wheat, canola and peas equations (as illustrated in Table 1, acreage elasticity with respect to variance of total profit are -0.10 spring wheat, 0.17 in canola and -0.10 in peas), all beta coefficients of the variance of total profit variable in the system are jointly statistically significant with p-values of 0.004 which indicates the importance of considering this effect in the model.

The lagged dependent variable was included in the acreage response model as an explanatory variable to control for the cost of adjustment in switching from one crop to another. Beta coefficients of the lagged dependent variable suggest that producers in the prairie responded

[35]Weights are the share of each crop acres in total acres during the period of study in three provinces

[36]Sandmo (1971) has examined the relationship between wealth effects, $\partial A^*/\partial w$, and the nature of risk preferences. In particular, a zero wealth effect, $\partial A^*/\partial w = 0$, corresponds to constant absolute risk aversion. In contrast, $\partial A^*/\partial w \neq 0$ corresponds to nonconstant absolute risk aversion. In the single-product case, Sandmo has shown that a positive wealth effect ($\partial A^*/\partial w > 0$) in supply response implies decreasing absolute risk aversion which is a maintained hypothesis in much of the economic literature (e.g., Arrow, 1965).

to market signals and government programs fairly slowly but differently across the various crops. In the case of rye, producers completed their response at a rate of 15 percent within a year, while for durum wheat producers completed their response at a rate of nearly 75 percent within a year.

Table1: Estimated Elasticities

	Equation	Prof swh	Prof dwh	Prof oats	Prof barley	Prof rye	Prof peas	Prof flax	Prof canola	Prof hay	Var swh	Var dwh
	swh acre											
Elasticity		0.199**	-0.019	-0.023	0.028	-0.011	0.022	0.005	-0.172**	0.003	-0.017	0.035
Std. Err.		0.061	0.034	0.015	0.028	0.007	0.018	0.023	0.046	0.010	0.021	0.028
	dwh acre											
Elasticity		-0.073	-0.048	-0.055	0.123	-0.013	0.012	-0.022	0.184	0.019	0.037	-0.063
Std. Err.		0.129	0.144	0.038	0.081	0.020	0.055	0.066	0.128	0.027	0.077	0.096
	oats acre											
Elasticity		-0.161	-0.103	0.211**	0.124*	0.059**	-0.066	0.011	-0.060	-0.019	-0.038	0.007
Std. Err.		0.109	0.071	0.062	0.077	0.028	0.049	0.073	0.101	0.036	0.039	0.052
	barley acre											
Elasticity		0.060	0.069	0.037*	-0.043	-0.008	-0.001	0.001	-0.071	0.023	0.038	-0.010
Std. Err.		0.060	0.046	0.023	0.058	0.012	0.026	0.034	0.057	0.017	0.026	0.032
	rye acre											
Elasticity		-0.635	-0.209	0.510**	-0.231	-0.044	-0.280	-0.385	0.454	0.172	0.031	-0.009
Std. Err.		0.412	0.317	0.237	0.333	0.206	0.230	0.375	0.415	0.197	0.151	0.187
	peas acre											
Elasticity		0.211	0.030	-0.091	-0.003	-0.045	0.007	0.183*	-0.184	-0.072	0.013	0.023
Std. Err.		0.173	0.141	0.068	0.121	0.037	0.116	0.107	0.185	0.053	0.080	0.096
	flax acre											
Elasticity		0.055	-0.060	0.016	0.005	-0.067	0.196*	0.578**	-0.507**	-0.346**	0.081	-0.115
Std. Err.		0.238	0.184	0.108	0.169	0.065	0.114	0.225	0.244	0.082	0.107	0.134
	canola acre											
Elasticity		-0.248**	0.070	-0.012	-0.048	0.011	-0.027	-0.070**	0.384**	-0.002	0.083	-0.182
Std. Err.		0.066	0.049	0.021	0.039	0.010	0.027	0.034	0.096	0.015	0.044	0.051
	hay acre											
Elasticity		0.008	0.015	-0.008	0.032	0.009	-0.022	-0.099**	-0.005	0.036**	-0.003	-0.037**
Std. Err.		0.032	0.021	0.015	0.024	0.010	0.016	0.023	0.031	0.018	0.010	0.013

Table 1: Continued

	Equation	Var oats	Var barley	Var rye	Var peas	Var flax	Var canola	Var hay	tot exp w	tot St. Err. w	lagged acre
	swh acre										
Elasticity		0.054**	-0.008	0.004	-0.033**	0.020	-0.002	-0.012	0.164**	-0.101**	0.549**
Std. Err.		0.016	0.012	0.019	0.020	0.015	0.021	0.018	0.086	0.035	0.048
	dwh acre										
Elasticity		-0.011	0.004	0.046	-0.071	-0.098**	0.285*	-0.050**	-0.328	0.100	0.247*
Std. Err.		0.062	0.033	0.056	0.062	0.049	0.078	0.053	0.223	0.116	0.099
	oats acre										
Elasticity		-0.052	0.007	0.091**	-0.004	0.006	0.003	-0.048	-0.213	0.095	0.657**
Std. Err.		0.034	0.024	0.034	0.038	0.028	0.041	0.036	0.162	0.081	0.083
	barley acre										
Elasticity		-0.026	-0.026**	-0.009	0.015	0.007	0.002	0.027	-0.160*	0.016	0.403**
Std. Err.		0.019	0.014	0.025	0.020	0.016	0.024	0.021	0.096	0.034	0.109
	rye acre										
Elasticity		0.061	0.011	0.092	0.033	0.039	0.112	-0.174	1.222**	0.236	0.868**
Std. Err.		0.123	0.090	0.124	0.151	0.100	0.131	0.142	0.617	0.204	0.197
	peas acre										
Elasticity		-0.028	-0.120**	-0.043	-0.049	-0.041	0.025	0.119**	-0.824	-0.108**	0.445**
Std. Err.		0.053	0.047	0.060	0.079	0.047	0.069	0.063	0.556	0.039	0.073
	flax acre										
Elasticity		-0.108	-0.034	0.133*	-0.131	-0.154**	0.225**	0.224**	-0.258	-0.010	0.662**
Std. Err.		0.082	0.061	0.080	0.088	0.075	0.101	0.087	0.385	0.122	0.095
	canola acre										
Elasticity		0.010	0.088	0.029	0.021	-0.104	-0.028	-0.039	0.031	0.172**	0.452**
Std. Err.		0.030	0.022	0.038	0.039	0.025	0.039	0.032	0.139	0.056	0.058
	hay acre										
Elasticity		-0.013	0.024**	-0.007	0.016*	-0.008	0.014	-0.048**	0.046	0.029	1.011**
Std. Err.		0.009	0.007	0.011	0.010	0.008	0.012	0.011	0.043	0.018	0.063

Notes: * is significant at 10 percent and ** is significant at 5 percent. Coef.=Coefficient; Std. Err.=Standard Error; prof=expected profit; Var=Variance; swh=spring wheat. dwh=durum wheat; exp. tot. w=expected total wealth; St. Err. tot. w=standard error of total wealth.

The estimated acreage response results reported above provide a basis for analyzing the effects of government direct payments on acreage planted to major field crops in the prairies. In this study, the effects of direct payments on acreage decisions are determined by finding the difference in total profit distribution parameters without direct payments, and total profit distribution parameters with direct payments. Then, using the estimated coefficients for expected total wealth and variance of total wealth (profit) we are able to calculate the acreage effects of direct payments. Specifically, we want to determine the effects of direct payments during the last decade, NISA (1991-2002) and CAIS (2003-2006), on the plantings of major field crops in the prairie provinces.

Table 2 shows values of parameters used in the simulation analysis of the effects of NISA for 1991-2002 and CAIS for 2003-2006 on acreage allocation, in Manitoba, Saskatchewan and Alberta. Specifically, this table presents the parameters of the total profit distribution with (truncated distribution) and without (untruncated distribution) the NISA and CAIS as the whole farm programs. For example, the truncation of CAIS on total (farm) profit distribution raises the expected farm profit in Saskatchewan to $2,391,969,105 (on average over 2003-2006), up from $1,788,496,668 in the absence of CAIS. Meanwhile, the truncation of CAIS lowers the standard deviation of farm profit to 482,366,585.3, down from 870,796,407.9.

Table 2: Parameter used for Simulation (in dollar)

	Without Program (Untruncated)			With Program (Truncated)	
	exp. tot. w	**Var tot. w**	**Trun. Point via NISA**	**exp. tot. w**	**Var tot. w**
(avg 1991-2002)					
MN	866075473.1	1.86285E+17	623944363	950629289.6	1.032E+17
SK	2669532172	9.55541E+17	1818619244	2786305430	6.12601E+17
AB	2093913300	9.51241E+17	1359337213	2224025282	5.65744E+17
(avg 2003-2006)			**Trun. Point via CAIS**		
MN	903051008.2	1.64206E+17	866432564.4	1057004360	6.49271E+16
SK	1788496668	7.58286E+17	2136169712	2391969105	2.32678E+17
AB	2036763336	2.47855E+17	2015502308	2491437718	8.95402E+16

Notes: exp. tot. w=expected total wealth; Var tot. w=variance of total wealth; Trun.=Truncation.
MN=Manitoba; SK=Saskatchewan; AB=Alberta.

Tables 3 and 4 present the simulation results for crops in which the coefficients of the expected total wealth (wealth effect) and total profit variance (insurance effect) are statistically significant (Spring wheat, Barley, Rye, Peas and Canola). As it can be seen, the source of effects of the NISA and CAIS on farmers' planting decisions in the prairie vary among crops, they affect spring wheat acreage through both wealth and insurance effects, barley and rye through the wealth effect and peas and canola through the insurance effect.

As Table 3 shows, NISA has considerably increased the acreage allocated to spring wheat in the prairie provinces. During 1991-2002, spring wheat acres increased on average by 9.25 percent in Manitoba, 5.34 percent in Saskatchewan and 11.12 percent in Alberta. Although both the wealth and insurance effects have a statistically significant role in acreage increase for spring wheat, the insurance effect is the major reason for the acreage response. Our results suggest that barley acres has decreased through the wealth effect as a result of NISA implementation. This effect, however, is small (0.28, 0.11 and 0.10 percent in Manitoba, Saskatchewan and Alberta, respectively). The decrease in acreage can also be seen in the case of canola, however, this reduction is due to the insurance effect. Based on the results, canola acreage has considerably decreased by 11.46, 8.75 and 12.63 percent in Manitoba, Saskatchewan and Alberta, respectively.

In the period of NISA implementation, peas acres have significantly increased through the insurance effect; on average by 15.18 percent in Manitoba, 3.22 percent in Saskatchewan and 11.02 percent in Alberta. The acres data show that the acreage planted to peas increased in the prairies during the 1991-2002 period, and therefore the insurance effect of NISA could be a reason for this increase in addition to the factors such as its profitability. Note that the peas acreage during 1981-1990 period was on average 119390, 114203 and 10396 acres in Manitoba,

Saskatchewan and Alberta respectively. During the NISA implementation these values increased to 168863.8, 1472928, 441485 (See Table F1 in Appendix F). An increase in acreage can also be seen in the case of rye, however, this increase is due to the wealth effect. Based on the results, rye acreage has slightly increased by 1.97, 0.77 and 1.22 percent in Manitoba, Saskatchewan and Alberta, respectively.

Table 3: Simulation Results of NISA (Whole-Farm Program over 1991-2002)

	Spring Wheat	Barley	Rye	Peas	Canola
MN-NISA Effect %					
Wealth Effect	0.20	-0.28	1.97	-	-
Insurance Effect	9.06	-	-	15.18	-11.46
Total Effect	9.25	-0.28	1.97	15.18	-11.46
SK-NISA Effect %					
Wealth Effect	0.08	-0.11	0.77	-	-
Insurance Effect	5.25	-	-	3.22	-8.75
Total Effect	5.34	-0.11	0.77	3.22	-8.75
AB-NISA Effect %					
Wealth Effect	0.19	-0.10	1.22	-	-
Insurance Effect	10.93	-	-	11.02	-12.63
Total Effect	11.12	-0.10	1.22	11.02	-12.63

As the Table 4 shows, the effect of CAIS on acreage decisions has a similar pattern to that of NISA, although its magnitude is different. As can be seen, CAIS has considerably increased the acreage allocated to spring wheat through both the wealth and insurance effects in the prairie provinces. Spring wheat acres expanded during 2003-2006, on average by 14 percent in Manitoba, 10.67 percent in Saskatchewan and 8.90 percent in Alberta. An expansion in acreage can also be seen in the cases of rye and peas. This increase in rye acreage is due to the wealth effect while the peas acreage increase is attributed to the insurance effect. Based on the results, peas acreage has considerably increased by 23.82, 2.72 and 5.50 percent in Manitoba, Saskatchewan and Alberta, respectively.

In contrast, in the period of CAIS implementation over 2003-2006, the acreage planted to barley and canola have decreased, the former through the wealth effect and the latter through the insurance effect. The insurance effect of CAIS led to a considerable decline in canola acreage, on average by 10.77 percent in Manitoba, 10.67 percent in Saskatchewan and 7.81 percent in Alberta. In general, except for few cases, it seems that CAIS has affected the acreage decisions proportionally more than the NISA.

Table 4: Simulation Results of CAIS (Whole-Farm Program over 2003-2006)

	Spring Wheat	Barley	Rye	Peas	Canola
MN-CAIS Effect %					
Wealth Effect	0.47	-0.66	3.49	-	-
Insurance Effect	13.53	-	-	23.82	-10.77
Total Effect	14.00	-0.66	3.49	23.82	-10.77
SK-CAIS Effect %					
Wealth Effect	0.57	-0.55	3.97	-	-
Insurance Effect	10.10	-	-	2.72	-10.67
Total Effect	10.67	-0.55	3.97	2.72	-10.67
AB-CAIS Effect %					
Wealth Effect	0.72	-0.40	4.26	-	-
Insurance Effect	8.18	-	-	5.50	-7.81
Total Effect	8.90	-0.40	4.26	5.50	-7.81

5 Conclusion

The shift of the farm subsidies toward programs classified as being decoupled income supports in the WTO's URAA raises the question of their true impact on production and trade. In this study, we measured the acreage effects of the Canadian whole farm programs under uncertainty. Based on the theoretical discussions regarding the role of the insurance effect in acreage decisions, we extend the theoretical restrictions examined by Chavas and Holt (1990) which enables us to include this effect in our model specification. Hence, we modified the expected utility maximization framework (under the hypothesis that farmers are risk averse) developed by Chavas and Holt (1990) and derived three distinct effects: market effects, the wealth effect, and the insurance effect. Government payments are incorporated into the model through truncation of the probability distribution of profits. Specifically, the whole-farm programs truncate the total (farm) profit distribution, which affect the expected total wealth and variance of total wealth. Within this model, a system of nine crop equations, for spring wheat, durum wheat, oats, barley, rye, peas, flax, canola and hay, is provided and all the relevant elasticities of acreage allocation with respect to the exogenous variables are estimated.

Based on the estimated results, the coefficients of expected total wealth and variance of total wealth were statistically significant in the whole system which implies that the whole-farm programs are production and therefore trade distorting and are not actually decoupled. The estimated statistically significant coefficients (for expected total wealth and variance of total wealth variables) were then used to simulate the impact of the NISA and CAIS programs. The NISA and CAIS programs have increased the acreage allocated to spring wheat, rye and peas while they have decreased the acreage for barley and canola in the prairie provinces. During 1991-2002, spring wheat acres increased, mostly through the insurance effect, on average by

9.25 percent in Manitoba, 5.34 percent in Saskatchewan and 11.12 percent in Alberta under the NISA. Under the CAIS, spring wheat acres expanded during 2003-2006; on average by 14 percent in Manitoba, 10.67 percent in Saskatchewan and 8.90 percent in Alberta. In the NISA period, peas acres increased, through insurance effect, on average by 15.18 percent in Manitoba, 3.22 percent in Saskatchewan and 11.02 percent in Alberta. Based on the results, under CAIS peas acreage increased considerably; by 23.82, 2.72 and 5.50 percent in Manitoba, Saskatchewan and Alberta, respectively. Our results suggest that canola acreage has considerably decreased by 11.46, 8.75 and 12.63 percent in Manitoba, Saskatchewan and Alberta, respectively under the NISA, while the reductions are 10.77, 10.67 and 7.81 percent under the CAIS. In general, our estimates confirm that the size and the direction of the acreage effect of direct payments are strongly influenced by the insurance effect. Therefore, for the whole farm programs, the total impact of the effects related to risk is important.

Hence, the implementation of decoupled programs calls into question the current definition of the Green Box payments in the WTO agricultural negotiations. There is a need to reevaluate the eligibility criteria of the Green Box payments. Current eligibility criteria do not take into account the farmer's response under uncertainty and are typically based on the market effects of policies. Since the size of the risk effects is relevant, especially the insurance effects, policies that are considered decoupled under the current WTO definition may not actually be production and trade neutral.

APPENDICES

Appendix A. Background: Canadian Agricultural Stabilization and Support Programs

Canadian agriculture has a long history of government involvement in programs designed to stabilize prices and incomes. From the time of Confederation in 1867 until the 1930s, identifying and attracting quality immigrants was a significant feature of national policy for agriculture. The Great Depression of the 1930s and the simultaneous droughts and insect damage throughout the North American Great Plains led to action by the federal government. In January 1935, the Canada government announced reforms which implied government intervention (as control and regulation) and, in turn the development of a policy for agriculture in Canada. From 1950s, government activities were transformed from simply control and regulation to direct provision of subsidies. In what follows, we will review agricultural stabilization and support programs in Canada starting in 1950.

After the Agricultural Products Board Act 1951 which stated that government should have a role to play in supporting agricultural prices and incomes, the federal government put into effect the Agricultural Stabilization Act (ASA) in 1958. ASA was the first Act in Canada which allocated direct payments to farmers that were fully funded by the Canadian government based on a specific formula to stabilize the low prices of a predetermined set of farm commodities. Under this Act, the federal government provided direct subsidies for nine commodities (cattle, hogs, sheep, butter, cheese, eggs, wheat, oats and barley not produced in the designated area defined in the Canadian Wheat Board Act) when the annual average price for any one of the named products dropped below 90 percent of the average price over the three preceding years. The amount of money paid under the ASA to farmers was initially small but started to grow

during a period of inflation in Canada starting in 1975. Since western farmers felt that price stabilization under ASA was not sufficient (in many years, the Canadian Wheat Board quotas for wheat, barley and durum were constraining, thus farmers could not deliver and get stabilization payments for all of their production), the WGSA was put in place to help prairie farmers stabilize their crop income. After the introduction of the Western Grain Stabilization Act in 1976, western grains were removed from the Agriculture Stabilization Act.

A second important policy was put in place through the Crop Insurance Act, 1959. Based on this Act, the Federal Government provided funds to the provinces to operate subsidized crop insurance programs within each province. The Crop Insurance Act was the first agricultural support program which introduced the concept of cost sharing between the federal and provincial governments. Protection offered under the crop insurance program only insured 60 percent of long-term yields. In 1996, the Federal Crop Insurance Act was amended in an attempt to increase farmer participation in the program. Since 1996, the insurance yield coverage level available to farmers had been increased from 60 percent of the long-term, average-area yield to 80 percent of the long-term, average-area yield. Also, the federal contribution to farmer premiums increased from 20 percent to 25 percent. Since all crop insurance contracts guarantee a price, in 1996 government began to offer insurance to farmers that was based on a futures price.

In 1976, the Western Grain Stabilization Act (WGSA) was passed to provide crop income stability for western grains and oilseeds. Under the WGSA, the total value of payout to all farmers in a given year was based on producers' eligible grain sales. Payment were made when aggregate net cash flow (cash receipts minus cash variable costs) from eligible grain (wheat, oats, barley, rye, flaxseed, canola and mustard seed; from 1988 nine crops are added to the seven previously covered – triticale, mixed grains, sunflower, safflower, buckwheat, peas,

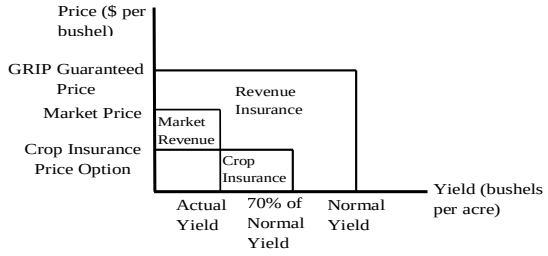
lentils, fababeans, canary seed) sales were less than the average net cash flow over the previous five years. The individual farmer's share of this payout was then determined by comparing the farmer's contributions to the programme (levies) in the current and the previous two years with total levies of all farmers over the same period. One third of programme costs were paid by farmers, and participation in the programme was optional. The WGSA was the first support program with fixed producer-federal government shares, and a composite of commodities; not support for each specific commodity. Under the WGSP the payouts were not large until after the grain trade wars of 1985. The program built up a large surplus in the early 1980s. In 1984, the payout triggers were changed to allow greater payouts to producers. However, the large payouts in the late 1980s led to a deficit in the WGSP fund. It was subsequently replaced with a new program called the Farm Income Protection Act (which had three components, the Gross Revenue Insurance Program, the Net Income Stabilization Account, and Crop Insurance).

As a result of the low grain prices in 1986, the government of Canada announced a new program was called the Special Canadian Grains Program. Under this program, $1 billion in 1986, $1.2 billion in 1987, $750 million in 1988, and $1 billion in 1989 were paid to producers. With several years of *ad hoc* programming experience and little improvement foreseen by governments, the federal and provincial governments began a major policy review in 1989. The economic difficulty felt by governments was that farmers in the crops sector were increasingly making planting and crop choice decisions based on governmental programming rather than market signals. The product of these debates was the Gross Revenue Insurance Program (GRIP) in 1991.

The Gross Revenue Insurance Program (GRIP) was the first program introduced under the Farm Income Protection Act. In GRIP, farmers were guaranteed a per acre gross return on

whatever crop they grew. A farmer would pay a premium to the insure gross revenues of a crop at a certain level, and he/she would receive an indemnity when area revenues fell below the coverage level. Premiums were subsidized (typically producers would pay 1/3 of the insurance premium). There were two payouts that compromised GRIP: (1) revenue insurance and (2) crop insurance. The program guaranteed producers their long-term average yield. The guaranteed price was set by an indexed moving average price. This index was an average of prices from the previous fifteen years, lagged by two years, indexed by a farm input price index which was used to index the grain price by a cost of production formula. As shown in figure 1, revenue insurance provided revenue protection between the level offered by crop insurance and the target revenue set by GRIP. Crop insurance provided a production guarantee equal to 70 percent of the producer's normal production times the price listed in the crop insurance contract. To collect the revenue insurance, the market revenue had to be below the target revenue.

Figure 1: The Mechanics of the GRIP



(Schmitz et al. 2002)

Saskatchewan had withdrawn from the program just eighteen months after it was implemented, because it was considered too expensive for the province and it was poorly designed. By 1999, the only province still in GRIP was Ontario.

The Net Income Stabilization Account (NISA), which has tripartite (federal, provincial

and farmer) funding, was the second program introduced in the Farm Income Protection Act. The stated purpose of the Net Income Stabilization Account (NISA) program of 1991-2002 was to encourage farmers to save more funds in high income years for use in low income years, so as to smooth incomes over time (this is similar to the objective of the WGSA. Unlike WGSA, each participant has an individual NISA account). NISA is a voluntary farm income safety net scheme, where farmers can set aside money in individual accounts which is then matched by federal and provincial government. A farmer can contribute up to 3 percent of eligible net sales as savings to a Fund one NISA account and the federal and provincial governments generally make a matching contribution to a Fund two NISA account for the individual (2 percent from the federal government and 1 percent from the provincial government). Matching funds earn a competitive interest rate, but the farmer's own deposits receive a 3 percent interest bonus paid by government. In addition, a farmer can contribute up to an additional 20 percent of eligible net sales to his Fund one NISA account. These additional farmer contributions are not matched by government, but they earn the 3 percent interest bonus from government. Farmer contributions are not tax deductible. All interest from both accounts is accumulated in Fund two. The maximum net sales for the qualifying matching government contribution is set at Cdn $250,000 per farm.

In years of declining income, farmers can withdraw funds from their NISA accounts in amounts determined by either one of two trigger mechanisms. Under the stabilization trigger, if, in tax year, the farm income falls below 70 percent of the previous three-year average, a farmer may withdraw money from his NISA account. Under the second trigger, if the farmer's net farm income falls below Cdn $10,000, the farmer may choose to withdraw his money from his NISA account. In all cases, a farmer's NISA account cannot be in deficit. This trigger was increased in

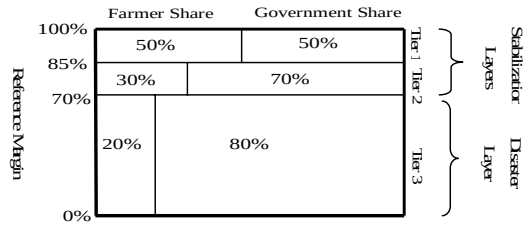
1999 to Cdn $20,000 per farm or Cdn $30,000 for cases in which the NISA account was held as a partnership.

In response to the drop in grains and oilseed prices, in 1998, the federal government introduced a temporary farm income support program called Agricultural Income Disaster Assistance (AIDA). This program was designed to meet the criteria of the WTO Annex for Green Box. When farmers' net income fell below 70 percent of their three-year, moving–average net income they become eligible for a pay-out (net income below zero is not included in the averaging process). The cost share on this program was 60 percent from the federal government and 40 percent from the provincial government. Since AIDA was costly in terms of the number of accountants and government employees needed to manage the individual farmers' AIDA application (which result in farmers receiving less than the full benefits of the program), the Canadian government in 2001 announced the Canadian Farm Income Program (CFIP). Even though CFIP replaces AIDA, it is similar to it.

The Canadian Agricultural Income Stabilization (CAIS), which is now Canada's single safety net program, was approved in late 2003 in place of the Net Income Stabilization Account (NISA), Canadian Farm Income Plan (CFIP) and related provincial programs. A production margin is intended to reflect revenues and expenses that are directly related to production for the firm and is calculated by subtracting farmer's total allowable expenses from his total allowable income. A reference production margin is an average of the five previous production margins for the farmer, excluding the high and low margins. A CAIS payment is triggered when a farmer's program year production margin declines below his reference margin (CAIS payouts are based on farm specific losses relative to reference margin rather than on a regional measure of loss as in the Western Grain Stabilization Act). The greater the decline in margin, the greater the

payment. Payments are financed from farmer deposits and government contributions, and shares vary with the difference relative to the reference margin, the amount of government funds the farmer will receive is determined by the extent of his margin decline. As shown in figure 2, the program measures the extent of farmer decline using three tiers, with Tier 1 representing the smallest decline, farmer deposits cover 1/2 of 0 to 15 percent loss, Tire 2, farmer deposits cover 3/10 of 15 to 30 percent loss, and Tier 3 representing the largest decline, farmer deposits cover 1/5 of loss greater than 30 percent. The government finances 60 percent of negative production margins. The share of a farmer is inversely proportional to loss. Farmer deposits must be a minimum of 14 percent of the current reference production margin; these deposits are not a premium and the farmer gets the money back.

Figure 2: The Mechanics of the CAIS



(CAIS Program Handbook)

Appendix B. Untruncated Mean, Variance and Covariance of Profits

By assuming that both price (p_i) and yield per acre (y_i) are random variables (to reflect not only price risk, but also production risk facing producers) and costs of production for i th crop (c_i) are constant, we can derive the untruncated expected profit for ith crop as follows:

$$\bar{\pi}_i = E(\pi_i) = E(p_i y_i - c_i) = E(p_i y_i) - c_i = Cov(p_i, y_i) + E(p_i).E(y_i) - c_i \tag{31}$$

To analyze supply behavior under risk, assumptions about the expectations of prices ($E(p_i)$) and yields ($E(y_i)$) are needed. We can use adaptive expectations for the normalized prices and yields. That is,

$$E_{t-1}(p_{it}) = \alpha_i + p_{i,t-1} \tag{32}$$

where $\alpha_i = E(p_{it} - p_{i,t-1})$ as measured by the sample mean of the past differences between observed prices and prices in the previous period. This computed mean is updated in each period. The assumption stated in (32) that expected prices are a function of the average price of the previous year has been successfully employed in previous research (e.g., Houck et al., 1976; Chavas, Pope, and Kao, 1983). Similarly, adaptive expectations for the normalized yields is

$$E_{t-1}(y_{it}) = \alpha_i' + y_{i,t-1} \tag{33}$$

where $\alpha_i' = E(y_{it} - y_{i,t-1})$ as measured by the sample mean of the past differences between observed yields and yields in the previous period. This computed mean is updated in each period. The covariance measure used for normalized prices and yields is

$$\begin{aligned} Cov(p_i, y_i) \quad &= \sum_{j=1}^{3} \omega_j [(p_{i,t-j} - E_{t-j-1}(p_{i,t-j})).(y_{i,t-j} - E_{t-j-1}(y_{i,t-j}))] = \\ &0.5[(p_{i,t-1} - E_{t-2}(p_{i,t-1})).(y_{i,t-1} - E_{t-2}(y_{i,t-1}))] + \\ &0.33[(p_{i,t-2} - E_{t-3}(p_{i,t-2})).(y_{i,t-2} - E_{t-3}(y_{i,t-2}))] + \\ &0.17[(p_{i,t-3} - E_{t-4}(p_{i,t-3})).(y_{i,t-3} - E_{t-4}(y_{i,t-3}))] \end{aligned} \tag{34}$$

where ω_j represents the declining weighting scheme. These measurements of covariance are also consistent with those used previously in the literature (e.g., Chavas and Holt, 1990; Coyle, Wei and Rude, 2008; Lin and Dismukes, 2007). By calculating relations (32), (33), and (34) and replacing into relation (31) we can calculate the untruncated expected profits for ith crop ($i = 1,2,,9$) in \$/acre in each province (Manitoba, Saskatchewan and Alberta) over years 1971-2006[37].

We follow Bohrnstedt and Goldberger (1969) to calculate untruncated crop profit variance and covariance (σ) for the product of two random variables. Variance for this bivariate profit distribution is (crop costs are assumed constant, resulting in gross revenue and net revenue variance and covariance being the same),

$$\begin{aligned}\sigma_{ii} = \; & Var(p_i y_i - c_i) = Var(p_i y_i) = E[p_i y_i - E(p_i y_i)]^2 = [E(p_i)]^2 Var(y_i) + [E(y_i)]^2 Var(p_i) + \\ & E[(p_i - E(p_i))^2 . (y_i - E(y_i))^2] + 2E(p_i).E[(p_i - E(p_i)).(y_i - E(y_i))^2] + \\ & 2E(y_i).E[(y_i - E(y_i)).(p_i - E(p_i))^2] + 2E(p_i).E(y_i).Cov(p_i, y_i) - (Cov(p_i, y_i))^2\end{aligned} \tag{35}$$

If p_i and y_i are bivarite normally distributed, $[(p_i - E(p_i))^2 . (y_i - E(y_i))^2] = Var(y_i).Var(p_i) + 2(Cov(p_i, y_i))^2$ and all third and higher moments are zero. The variance equation reduces to

$$\begin{aligned}Var(p_i y_i - c_i) \; & = [E(p_i)]^2 Var(y_i) + [E(y_i)]^2 Var(p_i) + 2E(p_i)E(y_i)Cov(p_i, y_i) + \\ & Var(y_i)Var(p_i) + (Cov(p_i, y_i))^2\end{aligned} \tag{36}$$

where $Var(p_i)$ is price variance and $Var(y_i)$ is yield variance and can be calculated as

[37]Nine untruncated expected profits have been calculated over 1971-2006 for each province.

$$Var(p_i) = \sum_{j=1}^{3} \omega_j [(p_{i,t-j} - E_{t-j-1}(p_{i,t-j})]^2 = 0.5[(p_{i,t-1} - E_{t-2}(p_{i,t-1}))]^2 + 0.33[(p_{i,t-2} - E_{t-3}(p_{i,t-2}))]^2 + 0.17[(p_{i,t-3} - E_{t-4}(p_{i,t-3}))]^2 \quad (37)$$

and

$$Var(y_i) = \sum_{j=1}^{3} \omega_j [(y_{i,t-j} - E_{t-j-1}(y_{i,t-j}))]^2 = 0.5[(y_{i,t-1} - E_{t-2}(y_{i,t-1}))]^2 + 0.33[(y_{i,t-2} - E_{t-3}(y_{i,t-2}))]^2 + 0.17[(y_{i,t-3} - E_{t-4}(y_{i,t-3}))]^2 \quad (38)$$

Expression (37) states that the variance of price is a weighted sum of the squared deviations of past prices from their expected values, with declining weights. These measurements of price risk are also consistent with those used previously in the literature (e.g., Lin, 1977; Traill, 1978; Lin and Dismukes, 2007). When price and/or yield are not bivariate normally distributed, (36) represents an approximation of variance of profits. The amount of error introduced into variance calculations by using (36) instead of (35) depends on the degree to which the price and/or yield distributions are non-normal, in combination with the magnitude of price and yield variance.

The untruncated covariance of crop profit between two crops is

$$Cov(p_i y_i, p_j y_j) = E(y_i)E(y_j)Cov(p_i, p_j) + E(p_i)E(y_j)Cov(y_i, p_j) + Cov(y_i, p_j)Cov(p_i, y_j) + Cov(p_i, p_j)Cov(y_i, y_j) + E(p_i)E(p_j)Cov(y_i, y_j) + E(y_i)E(p_j)Cov(p_i, y_j) \quad (39)$$

where $Cov(p_i, p_j)$ is covariance between prices for crops i and j, with other covariances defined in a similar manner and all covariances in relation (39) can be calculated using a relation similar to (34). Relation (39) collapses to (36) when $i = j$. Thus, relation (39) could be used to calculate each element of a $n \times n$ untruncated variance-covariance matrix (σ), where n is the number of crops included in the analysis. Using relation (39), we can calculate the untruncated covariance of cross-commodity profits between ith and jth crops ($i = 1,2,,9$) in each province

(Manitoba, Saskatchewan and Alberta) over years 1971-2006[38].

Both expected profits and the corresponding elements of the variance-covariance matrix are influenced by the existence of the government programs, which truncates the profit distribution at the minimum profit level. Assuming a multivariate normal distribution for profits, the computed expected profits, variances and covariances should be corrected for this truncation. The influence of government programs on the subjective probability distribution of profits for each crop ($\pi_i = (p_i y_i - c_i)$) is considered by crop-specific programs, Crop Insurance, Agricultural Stabilization Act, and GRIP, over the period of our study. Therefore, a change in the government crop-specific support programs induces changes in the expected profits and in their variability (variance-covariance matrix) for each crop. Now, assume that each random variable profit ($\pi_i = (p_i y_i - c_i)$) is truncated from below at a level H_i (which is the higher guaranteed profit by crop-specific programs[39]). Expressions (43), (44), and (45) in Appendix C provide an analytical evaluation of the truncation effect of a crop-specific program on the mean, variance, and covariance of commodity profits.

[38]In our study, since the number of crops is nine, thirty six untruncated covariance of cross-commodity profits and nine variance of profits over 1971-2006 for each province have been calculated.

[39]The calculation of guaranteed profit by crop-specific government support programs is discussed in the text.

Appendix C. Truncated Mean, Variance and Covariance of Profits: Incorporation of Government Programs into the Model

The acreage decision model (6) involves uncertainty about prices p and yields y. In this appendix the influence of government programs on the subjective probability distribution of profits Π is considered. The resulting truncation of the subjective probability distribution of profits will affect expected profits ($\overline{\Pi}$) as well as second (σ) and higher moments of the profit distribution. Thus, a support program will influence both profit expectations and the riskiness of profit.

We consider the normal case since the effects of multivariate truncation are best understood in the context of a normal distribution (see Johnson and Kotz, 1972). Let $\Pi = (\pi_1, \pi_2, ...)$ be a vector of normally distributed random profits with mean $E(\Pi) = \overline{\Pi} = (\overline{\pi}_1, \overline{\pi}_2, ...)$ and variance $\sigma = E(\Pi - \overline{\Pi})'(\Pi - \overline{\Pi})$, where E is the expectation operator. Now, assume that each random profit π_i, is truncated from below at a level H_i. Define the truncated random profits

$$\pi_i^T = \begin{cases} H_i & if \quad \pi_i < H_i, \\ \pi_i & if \quad \pi_i \geq H_i, \end{cases} i = 1,2,...,n$$

Consider the standardized random profit $e_i = \frac{\pi_i^T - \overline{\pi}_i}{\sigma_{ii}^{1/2}}$ and define $h_i = \frac{H_i - \overline{\pi}_i}{\sigma_{ii}^{1/2}}$. The mean and variance of e_i are derived in Chavas and Holt (1990). The expected value of e_i, is

$$\overline{e}_i = E(e_i) = \phi(h_i) + h_i \Phi(h_i) \tag{40}$$

where $\phi(.)$ and $\Phi(.)$ are the standard normal density function and distribution function, respectively. The second moments of e_i, are given by

$$M_{ii} = E(e_i^2) = 1 - \Phi(h_i) + h_i \phi(h_i) + h_i^2 \Phi(h_i) \tag{41}$$

and if $i \neq j$,

$$M_{ij} = E(e_i e_j) = F(h_i, h_j)\rho_{ij} + [(1-\rho_{ij}^2)/2\times 3.14]^{1/2}\phi(Z_{ij}) + h_i\phi(h_j)\Phi(k_{ij}) + h_j\phi(h_i)\Phi(k_{ji}) + h_i h_j \Phi(h_i, h_j) \quad (42)$$

where $F(h_i, h_j) = prob(\pi_i \geq H_i, \pi_j \geq H_j) = \Phi(h_i, h_j) + 1 - \Phi(h_i) - \Phi(h_j)$, $\rho_{ij} = \sigma_{ij}/(\sigma_{ii}\sigma_{jj})^{1/2}$,

$Z_{ij} = \{, (h_i - 2p_{ij}h_i h_j + h_j)/(l-\rho_{ij}^2)^{1/2}$, $k_{ij} = (h_i - \rho_{ij}h_j)/(l-\rho_{ij}^2)$ and

$\Phi(h_i, h_j) = prob(\pi_i < H_i, \pi_j < H_j)$. It follows that the mean, variance, and covariance of $\Pi^T = (\pi_1^T, \pi_2^T, ...)$ are

$$\overline{\pi}_i^T = E(\pi_i^T) = \overline{\pi}_i + \sigma_{ii}^{1/2}\overline{e}_i \quad (43)$$

and,

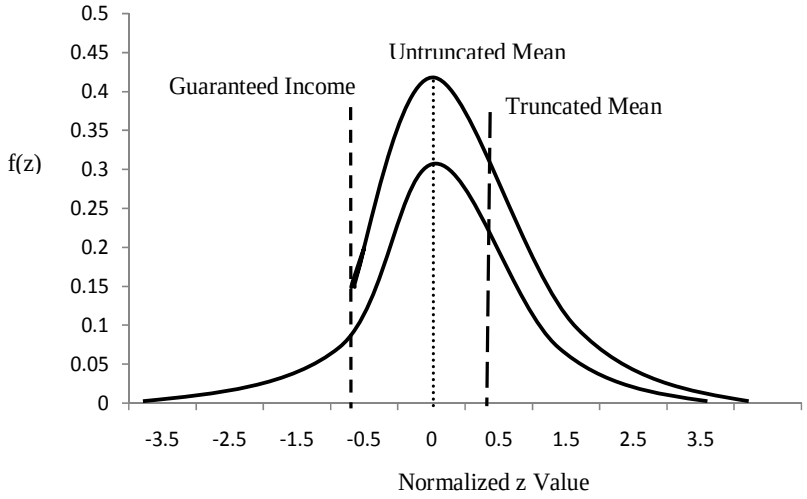
$$\sigma_{ii}^T = E(\pi_i^T - \overline{\pi}_i^T)^2 = \sigma_{ii}(M_{ii} - \overline{e}_i^2) \quad (44)$$

and,

$$Cov(\overline{\pi}_i^T, \overline{\pi}_j^T) = E(\pi_i^T - \overline{\pi}_i^T)(\pi_j^T - \overline{\pi}_j^T) = (\sigma_{ii}\sigma_{jj})^{1/2}(M_{ij} - \overline{e}_i\overline{e}_j) \quad (45)$$

The above expressions provide an analytical evaluation of the truncation effect of a support program on the mean, variance, and covariance of commodity profits. These results will be used to investigate the influence of government programs on crop acreage decisions. Figure C1 illustrates the effects of government programs on the mean and variance of commodity profit distribution. When untruncated expected commodity profits are substantially above the guaranteed income by government, the effect of government program on moments of the profit distribution will remain at a minimum. However, when truncated expected commodity profits are either slightly above the guaranteed income or actually below the guaranteed income, the effects on moments of the profit distributions will be more pronounced.

Figure C1: The Effects Of Government Program Truncation On Crop Profit Distribution



The above expressions show that to derive the truncated mean and variance-covariance of profits we need an untruncated mean and variance-covariance of profits ($\overline{\Pi}, \sigma$). The formula for untruncated mean and variance-covariance of profits were discussed in Appendix B.

As an example, consider spring wheat (swh) in Saskatchewan in 1997. Untruncated expected profit $\overline{\pi}_{swh}$ and untruncated expected variance of profit σ_{swh} have been obtained using relations (31) and (36), respectively. Guaranteed profits ($/acre) by Crop Insurance and GRIP programs (in 1997 there is no data for Agricultural Stabilization Act because this program has been terminated in 1984) for spring wheat have been calculated and then the higher guaranteed profit ($/acre) in year 1997 has been chosen as truncation point H_{swh}. Then, $h_{swh} = \frac{(H_{swh} - \overline{\pi}_{swh})}{\sigma_{swh}^{0.5}}$ has been calculated. $\phi(h_{swh}) = \frac{1}{(2\pi)^{0.5}} e^{-\frac{(h_{swh})^2}{2}}$ and $\Phi(h_{swh})$ has been calculated by $NORMSDIST(h_{swh})$ in Excel which provides the standard normal cumulative distribution function. Finally, the truncated expected profit and the truncated variance of profit for spring wheat in Saskatchewan in year 1997 have been obtained by replacing (40) and (41) into (43) and

(44), respectively.

To calculate the truncated covariance between profits of spring wheat and, for example, durum wheat (dwh), the untruncated covariance between spring wheat and durum wheat profits $\sigma_{swh,dwh}$, the untruncated variances of spring wheat profit σ_{swh} and durum wheat σ_{dwh} have been calculated using relations (39) and (36). Then, $\rho_{swh,dwh} = \frac{\sigma_{swh,dwh}}{(\sigma_{swh}.\sigma_{dwh})^{0.5}}$ has been obtained. $Z_{swh,dwh} = \left\{(h_{swh}{}^2 - 2\rho_{swh,dwh}h_{swh}h_{dwh} + h_{dwh}{}^2)/(1-\rho_{swh,dwh}{}^2)\right\}^{0.5}$, $k_{swh,dwh} = \frac{h_{swh} - \rho_{swh,dwh}h_{dwh}}{\left(1-\rho_{swh,dwh}{}^2\right)^{0.5}}$, $k_{dwh,swh} = \frac{h_{dwh} - \rho_{swh,dwh}h_{swh}}{\left(1-\rho_{swh,dwh}{}^2\right)^{0.5}}$ have been calculated. $\phi(Z_{swh,dwh}) = \frac{1}{(2\pi)^{0.5}} e^{-\frac{Z_{swh,dwh})^2}{2}}$, $\Phi\left(k_{swh,dwh}\right)$ and $\Phi\left(k_{dwh,swh}\right)$ have been obtained using $NORMSDIST\,(k_{swh,dwh})$ and $NORMSDIST\,(k_{dwh,swh})$ in Excel. $F\left(h_{swh}, h_{dwh}\right) = \Phi\left(h_{swh}, h_{dwh}\right) + 1 - \Phi\left(h_{swh}\right) - \Phi\left(h_{dwh}\right)$ in which $\Phi\left(h_{swh}, h_{dwh}\right)$ has been obtained using the $binormal\,(h_{swh}, h_{dwh}, \rho_{swh,dwh})$ command in Stata which returns the joint cumulative distribution of the bivariate normal with correlation ρ; cumulative over (-inf, h_{swh}] and (-inf, h_{dwh}]. Finally, the truncated covariance between spring wheat and durum wheat profits in Saskatchewan in 1997 has been calculated by replacing (42) into (45).

Therefore, using relations (43)(44) and (45), the truncated expected profit, $\bar{\pi}_j^T$ (which in our case of nine crops would be nine individual profit variables), and the truncated covariance of cross-commodity profits, σ_{jk}^T (which in our case would be nine individual variance variables and thirty six covariance variables), in equation (38) (or (39)) can be constructed in each province over 1971-2006.

Untruncated expected total (farm) profit for crops in $ is

$$\overline{\Pi} = E(\Pi) = \quad E(\sum_{i=1}^{n}\pi_i A_i) = E[(p_1y_1 - c_1).A_1 + (p_2y_2 - c_2).A_2 + ... + (p_ny_n - c_n).A_n] =$$
$$E[(p_1y_1 - c_1).A_1] + E[(p_2y_2 - c_2).A_2] + ... + E[(p_ny_n - c_n).A_n] = \quad (46)$$
$$[E(p_1y_1) - c_1].A_1 + [E(p_2y_2) - c_2].A_2 + ... + [E(p_ny_n) - c_n].A_n$$

in which each term in square bracket has been calculated using relation (31). The untruncated variance of total (farm) profit for crops is

$$A\sigma A' = \sigma_T = Var[(p_1y_1 - c_1).A_1 + (p_2y_2 - c_2).A_2 + ... + (p_ny_n - c_n).A_n] =$$
$$A_1^2[Var(p_1y_1)] + A_2^2[Var(p_2y_2)] + ... + A_n^2[Var(p_ny_n)] + 2A_1A_2[Cov(p_1y_1, p_2y_2)] +$$
$$2A_1A_3[Cov(p_1y_1, p_3y_3)] + ... + 2A_1A_n[Cov(p_1y_1, p_ny_n)] + 2A_2A_3[Cov(p_2y_2, p_3y_3)] + \quad (47)$$
$$2A_2A_4[Cov(p_2y_2, p_4y_4)] + ... + 2A_2A_n[Cov(p_2y_2, p_ny_n)] + ... + 2A_{n-1}A_n[Cov(p_{n-1}y_{n-1}, p_ny_n)]$$

in which each term in square bracket has been calculated using relation (36) and (39).

The influence of government programs on the subjective probability distribution of total profits is considered by whole-farm programs, WGSA, NISA, AIDA/CFIP, and CAIS, over the period of our study. The resulting truncation of the subjective probability distribution of total profits will affect expected total profits as well as second and higher moments of the total profit distribution. Thus, government whole-farm programs will influence both total profit expectations and the riskiness of total profit (variance). If we assume that each random variable total profit is truncated from below at a level H (which is the higher guaranteed profit by whole-farm programs[40]), expressions (43) and (44) in the above provide an analytical evaluation of the truncation effect of a whole-farm program on the mean and variance of total profit.

For example, consider Saskatchewan in 2005. The untruncated expected total profit and the untruncated variance of total profit have been obtained using relations (46) and (47), respectively. Guaranteed profit ($) by CAIS program (in 2005, WGSA, NISA or AIDA/CFIP

[40]The calculation of guaranteed profit by whole-farm support programs is provided in the text.

have been terminated) in 2005 has been calculated and then chosen as truncation point H. Then, $h = \frac{H - \overline{\Pi}}{\sigma_T^{0.5}}$ has been calculated. $\phi(h) = \frac{1}{(2\pi)^{0.5}} e^{-\frac{(h)^2}{2}}$ and $\Phi(h)$ has been calculated by *NORMSDIST* (h) in Excel which provides the standard normal cumulative distribution function. Finally, the truncated expected total profit and the truncated variance of total profit in Saskatchewan in 2005 have been obtained by replacing (40) and (41) in (43) and (44), respectively. Therefore, using relations (43) and (44), the truncated expected total profit ($\sum_{j=1}^{9} A_j \overline{\pi}_{jt}^{T}$) and the truncated variance of total profit ($\sum_{k \geq j} \sum_{j=1}^{9} A_j A_k \sigma_{jkt}^{T}$) in equation (38) (or (39)) can be constructed in each province for 1971-2006.

Appendix D. Hypothesized Signs on Model Parameters

Considering that the allocation of a given amount of land to different crops is similar to choosing an optimal portfolio of assets, we use portfolio theory to determine the hypothesized relationships between acreage of a given crop and each of the variables in equation (16) including profits, variances and covariances. Without loss of generality, by considering a three-product case, assume that producers choose the portfolio weights that maximize utility U with the common function (i.e. the utility function for profit is quadratic so that mean and variance are the only moments relevant to the decision maker's risky choice)[41]:

$$U = \overline{W} - \frac{1}{2}\tau\sigma_W \tag{17}$$

where $\overline{W}$ is expected total wealth, τ shows the coefficient of risk aversion ($\tau > 0$), while all risk-averse farmers seek to avoid risk, different farmers have different levels of risk aversion. Low values of τ are consistent with a higher tolerance for risk, while higher values for τ equate to higher degrees of risk aversion. σ_W is the variance of total wealth. We define $W = w + \Pi A'$ where total wealth W is initial wealth (w) and income from the market ($\Pi A'$). So we can write

$$U = w + \overline{\Pi}A' - \frac{1}{2}\tau A\sigma A' \tag{18}$$

where $A\sigma A' = \sigma_T$ is variance of total profit.

[41]In using the mean-variance model instead of the more general expected utility models, we should note that if the returns from a risky portfolio are judged to follow a normal distribution, mean-variance portfolio analysis is relevant even if the decision maker's utility function is not quadratic. The reason is that mean and variance-covariance completely specify the normal distribution. Therefore, if profits are normally distributed, the decision maker can rank alternatives using only two parameters, expected value and variance-covariance, without concern to the higher moments of the distribution. Moreover, Levy and Markowitz (1979) have demonstrated that the mean-variance model is appropriate as a second-order Taylor series approximation to all risk-averse utility functions. Modeling acreage response as in this study is one such application of the mean-variance theory that is being used in approximating expected utility as a function of expected profits and variance-covariance of profits.

In the three-crop case i, j, k the portfolio return is calculated as:

$$\overline{\Pi}A' = A_i\pi_i + A_j\pi_j + A_k\pi_k \tag{19}$$

where A_i, A_j, and A_k are the portfolio weights of crops i, j and k, respectively. These are the weights that producers adjust to maximize utility. The expected returns are given by π_i, π_j, and π_k, respectively. The portfolio variance is calculated as:

$$\sigma = A_i^2\sigma_i^2 + A_j^2\sigma_j^2 + A_k^2\sigma_k^2 + 2A_iA_j\sigma_{ij} + 2A_iA_k\sigma_{ik} + 2A_jA_k\sigma_{jk} \tag{20}$$

where $\sigma_{ij} = \sigma_i\sigma_j\rho_{ij}$ shows the covariance and ρ_{ij} is i, j crops' return correlation. The standard deviations of crops are given by σ_i, σ_j and σ_k. Portfolios are chosen by maximizing utility subject to the constraint:

$$\begin{aligned} Max \quad & U = A_i\pi_i + A_j\pi_j + A_k\pi_k - \frac{1}{2}\tau(A_i^2\sigma_i^2 + A_j^2\sigma_j^2 + A_k^2\sigma_k^2 \\ & + 2A_iA_j\sigma_{ij} + 2A_iA_k\sigma_{ik} + 2A_jA_k\sigma_{jk}) \\ s.t. \quad & A_i + A_j + A_k = 1 \end{aligned} \tag{21}$$

Substituting $(1 - A_i - A_j)$ for A_k into utility function U puts the problem in terms of just two unknowns A_i and A_j:

$$\begin{aligned} Max \quad & U = A_i\pi_i + A_j\pi_j + (1 - A_i - A_j)\pi_k - \frac{1}{2}\tau(A_i^2\sigma_i^2 + A_j^2\sigma_j^2 + (1 - A_i - A_j)^2\sigma_k^2 \\ & + 2A_iA_j\sigma_{ij} + 2A_i(1 - A_i - A_j)\sigma_{ik} + 2A_j(1 - A_i - A_j)\sigma_{jk}) \end{aligned} \tag{22}$$

The optimal portfolio weight in i, A_i, can be found by setting $\partial U/\partial A_i = 0$ and solving for A_i which gives:

$$A_i = \frac{\pi_i - \pi_k + \tau(\sigma_k^2 - \sigma_{ik}) - \tau A_j(\sigma_k^2 - \sigma_{ik} + \sigma_{ij} - \sigma_{kj})}{\tau(\sigma_i^2 + \sigma_k^2 - 2\sigma_{ik})} \tag{23}$$

In this solution, the optimal portfolio weight in A_i is a function of A_j, which is also unknown. Setting $\partial U/\partial A_j = 0$ and solving for A_j results in:

$$A_j = \frac{\pi_j - \pi_k + \tau(\sigma_k^2 - \sigma_{jk}) - \tau A_i(\sigma_k^2 - \sigma_{ik} + \sigma_{ij} - \sigma_{kj})}{\tau(\sigma_j^2 + \sigma_k^2 - 2\sigma_{jk})} \tag{24}$$

If we assume $\sigma_i^2 + \sigma_k^2 - 2\sigma_{ik} = X$, $\sigma_j^2 + \sigma_k^2 - 2\sigma_{jk} = Y$[42], $\sigma_k^2 - \sigma_{ik} + \sigma_{ij} - \sigma_{kj} = Z$, substituting A_j of equation (24) in equation (23), after some rearranging, leads to the following:

$$A_i = \frac{[\pi_i - \pi_k + \tau(\sigma_k^2 - \sigma_{ik})]Y - [\pi_j - \pi_k + \tau(\sigma_k^2 - \sigma_{kj})]Z}{\tau(XY - Z^2)} \tag{25}$$

Solving for $\partial A_i/\partial \pi_i$ shows the impact of a change in own return, π_i, on the optimal portfolio weight of i and is given by:

$$\partial A_i/\partial \pi_i = \frac{Y}{\tau(XY - Z^2)} > 0 \tag{26}$$

Since $Y > 0$, $\tau > 0$ and $(XY - Z^2) > 0$[43], then the effect of changes in own return on A_i,

[42]Since $(\sigma_i - \sigma_k)^2 = (\sigma_i^2 + \sigma_k^2 - 2\sigma_i\sigma_k) > 0$ and $\sigma_{ik} = \sigma_i\sigma_k\rho_{ik}$, $-1 < \rho_{ik} < 1$, then $X, Y > 0$.

[43]The second-order-condition of the optimization problem in (22) implies

$\partial A_i/\partial \pi_i > 0$, is positive. The degree of the increase in portfolio weight is dependent upon the variances and covariances of crop returns and the risk aversion of the individual producer. The effect of changes in cross-returns on A_i, $\partial A_i/\partial \pi_j$ and $\partial A_i/\partial \pi_k$ cannot be signed.

The marginal impact of changes in σ_i^2 on the optimal portfolio weight in i, is given by solving for $\partial A_i/\partial \sigma_i^2$:

$$\partial A_i/\partial \sigma_i^2 = \frac{-([\pi_i - \pi_k + \tau(\sigma_k^2 - \sigma_{ik})]Y - [\pi_j - \pi_k + \tau(\sigma_k^2 - \sigma_{kj})]Z)(\tau Y)}{[\tau(XY - Z^2)]^2} < 0 \qquad (27)$$

Since $Y > 0$, $\tau > 0$ and $([\pi_i - \pi_k + \tau(\sigma_k^2 - \sigma_{ik})]Y - [\pi_j - \pi_k + \tau(\sigma_k^2 - \sigma_{kj})]Z) > 0$[44], therefore the effect of changes in own variance on A_i, $\partial A_i/\partial \sigma_i^2 < 0$, is negative. The effect of changes in cross-variances on A_i, $\partial A_i/\partial \sigma_j$ and $\partial A_i/\partial \sigma_k$ cannot be signed.

To find the marginal impact of changes in ρ_{ik} on the optimal portfolio weight in i, solve for $\partial A_i/\partial \rho_{ik}$, which gives:

$$|H| = \begin{vmatrix} \frac{\partial^2 U}{\partial A_i^2} & \frac{\partial^2 U}{\partial A_i A_j} \\ \frac{\partial^2 U}{\partial A_j A_i} & \frac{\partial^2 U}{\partial A_j^2} \end{vmatrix} < 0,$$

$|H| = \begin{vmatrix} -X & -Z \\ -Z & -Y \end{vmatrix} = -(XY - Z^2) < 0$ which gives $(XY - Z^2) > 0$.

[44]Since A_i implies the weight of crop i in portfolio, it should be positive ($0 < A_i < 1$). Thus, in equation (25) the numerator should have the same sign as denominator. Since denominator is positive ($(XY - Z^2) > 0$), the numerator has the positive sign, $([\pi_i - \pi_k + \tau(\sigma_k^2 - \sigma_{ik})]Y - [\pi_j - \pi_k + \tau(\sigma_k^2 - \sigma_{kj})]Z) > 0$.

$$\partial A_i/\partial \rho_{ik} = \frac{2\sigma_i\sigma_k Y(Y-Z)[\pi_i - \pi_k + \tau(\sigma_k^2 - \sigma_{ik})] - \tau\sigma_i\sigma_k Y(XY - Z^2)}{\tau(XY - Z^2)^2}$$
$$+ \frac{\sigma_i\sigma_k[(XY - Z^2) + 2\sigma_i\sigma_k Z(Z-Y)][\pi_j - \pi_k + \tau(\sigma_k^2 - \sigma_{kj})]}{\tau(XY - Z^2)^2} \quad (28)$$

This reveals the impact that a change in the i and k correlation will have on the optimal weight in i. The marginal effect is determined by the variances and covariances of crop returns, the risk aversion parameter of the individual producer, and the risk premiums ($\pi_i - \pi_k$ and $\pi_j - \pi_k$).

Although in the three-product case (or N products case) we can just determine the expected sign for own return and variance, it is obvious that in the two crops case there is expected sign for all variables because $\partial A_j/\partial \pi_i$ is equal to $-\partial A_i/\partial \pi_i$, $\partial A_j/\partial \sigma_i^2$ is equal to $-\partial A_i/\partial \sigma_i^2$, and $\partial A_j/\partial \rho_{ij}$ is equal to $-\partial A_i/\partial \rho_{ij}$.

Appendix E.

Table E1: Estimated Results

		Prof swh	Prof dwh	Prof oats	Prof barley	Prof rye	Prof peas	Prof flax	Prof canola	Prof hay	Var swh
	swh acre										
Coef.		18331.98**	-1463.29	-2465.47	2515.45	-1591.68	1326.53	351.74	-9318.54**	304.50	-171.10
Std. Err.		5588.78	2586.99	1665.42	2510.22	1028.97	1085.13	1523.04	2467.16	1229.40	209.28
	dwh acre										
Coef.		-1463.29	-799.00	-1300.02	2405.98	-432.32	155.44	-316.62	2173.47	477.52	81.07
Std. Err.		2586.99	2377.59	899.06	1590.82	654.56	730.22	971.50	1506.94	690.03	169.79
	oats acre										
Coef.		-2465.47	-1300.02	3806.22**	1857.21	1503.99**	-672.18	123.80	-537.53	-382.15	-64.01
Std. Err.		1665.42	899.06	1111.20	1149.69	692.92	499.76	810.66	911.76	703.34	65.21
	barley acre										
Coef.		2515.45	2405.98	1857.21	-1769.10	-562.44	-19.16	34.05	-1755.30	1215.08	175.05
Std. Err.		2510.22	1590.82	1149.69	2359.17	810.61	741.53	1049.46	1416.28	923.41	120.15
	rye acre										
Coef.		-1591.68	-432.32	1503.99**	-562.44	-181.76	-467.11	-700.86	668.67	551.33	8.38
Std. Err.		1028.97	654.56	692.92	810.61	847.42	382.82	682.38	608.97	630.19	41.36
	peas acre										
Coef.		1326.53	155.44	-672.18	-19.16	-467.11	27.60	838.03*	-679.10	-576.07	8.91
Std. Err.		1085.13	730.22	499.76	741.53	382.82	484.74	485.93	680.91	427.07	54.84
	flax acre										
Coef.		351.74	-316.62	123.80	34.05	-700.86	838.03*	2689.22**	-1906.48**	-2828.36**	56.37
Std. Err.		1523.04	971.50	810.66	1049.46	682.38	485.93	1043.45	915.36	664.27	74.97
	canola acre										
Coef.		-9318.54**	2173.47	-537.53	-1755.30	668.67	-679.10	-1906.48**	8454.26**	-104.66	338.47**
Std. Err.		2467.16	1506.94	911.76	1416.28	608.97	680.91	915.36	2100.76	702.32	181.13
	hay acre										
Coef.		304.50	477.52	-382.15	1215.08	551.33	-576.07	-2828.36**	-104.66	1843.24**	-10.99
Std. Err.		1229.40	690.03	703.34	923.41	630.19	427.07	664.27	702.32	875.32	43.73

Table E1: Continued

	Var dwh	Var oats	Var barley	Var rye	Var peas	Var flax	Var canola	Var hay	tot exp w	tot St. Err. w	lagged acre
swh acre											
Coef.	151.03	325.00**	-83.34	41.55	-99.47*	108.47	-9.36	-118.03	0.000090**	-0.001375**	0.54**
Std. Err.	117.89	96.41	122.68	173.37	58.28	81.84	82.10	176.24	0.000047	0.000478	0.05
dwh acre											
Coef.	-58.92	-13.75	9.41	92.97	-46.00	-117.38**	246.35**	-110.09	-0.000039	0.000296	0.25**
Std. Err.	88.91	80.55	71.69	114.09	40.29	58.24	67.51	114.60	0.000026	0.000343	0.10
oats acre											
Coef.	4.96	-51.39	11.10	142.64**	-1.98	5.30	2.11	-79.42	-0.000019	0.000216	0.66**
Std. Err.	37.05	33.91	39.66	53.51	18.78	25.30	26.82	58.90	0.000015	0.000185	0.08
barley acre											
Coef.	-19.54	-70.22	-122.06**	-38.21	20.13	16.80	4.32	124.42	-0.000040*	0.000097	0.40**
Std. Err.	62.77	51.03	62.38	106.29	27.53	39.60	43.53	93.82	0.000024	0.000209	0.11
rye acre											
Coef.	-1.09	9.95	3.02	23.40	2.63	5.84	12.09	-47.25	0.000018**	0.000088	0.85**
Std. Err.	21.66	19.91	24.44	31.30	12.20	14.84	14.10	38.42	0.000009	0.000076	0.19
peas acre											
Coef.	6.64	-11.21	-82.26**	-27.53	-9.95	-15.37	6.62	80.92	-0.000031	-0.000100**	0.48**
Std. Err.	27.91	21.70	31.97	38.08	15.99	17.33	18.48	42.62	0.00002	0.00003	0.08
flax acre											
Coef.	-33.87	-44.89	-23.30	86.55*	-26.94	-58.46**	61.91**	155.39**	-0.000010	-0.000009	0.68**
Std. Err.	39.63	33.93	42.61	51.80	18.11	28.35	27.58	59.54	0.000015	0.000115	0.09
canola acre											
Coef.	-315.29**	23.36	359.28**	109.75	25.05	-230.25**	-45.21	-156.72	0.000007	0.000956**	0.47**
Std. Err.	87.48	73.64	88.37	142.57	47.18	55.48	62.41	129.35	0.000031	0.000311	0.06
hay acre											
Coef.	-66.89**	-33.13	103.12**	-25.75	20.49*	-18.68	22.86	-203.05**	0.000011	0.000169	1.04**
Std. Err.	23.30	22.92	30.24	44.01	12.02	19.01	19.37	45.63	0.000010	0.000106	0.07

Notes: * is significant at 10 percent and ** is significant at 5 percent. Coef.=Coefficient; Std. Err.=Standard Error; prof=expected profit; Var=Variance; swh=spring wheat. dwh=durum wheat; exp. tot. w=expected total wealth; St. Err. tot. w=standard error of total wealth.

Table E2: Estimated Results

	swh acre	Cov swh,dwh	Cov swh,flax	Cov swh,cano	Cov swh,hay	Cov dwh,oats	Cov dwh,rye	Cov dwh,peas	Cov dwh,cano	Cov oats,rye
Coef.		157.70**	125.38**	-59.66	-203.34**	-102.51**	-22.98	41.79	-130.83**	91.33**
Std. Err.		51.72	39.39	37.80	49.75	31.48	21.32	26.19	34.98	30.26
	dwh acre	Cov swh,dwh	Cov swh,oats	Cov swh,barl	Cov swh,cano	Cov swh,hay	Cov dwh,barl	Cov dwh,peas	Cov dwh,flax	Cov dwh,flax
Coef.		-4.07	-10.85	16.31	50.94*	19.22	-21.21	-23.24	20.07	8.14
Std. Err.		36.23	24.51	31.00	29.24	33.44	60.73	20.61	29.78	35.53
	oats acre	Cov swh,flax	Cov swh,cano	Cov swh,hay	Cov dwh,peas	Cov dwh,flax	Cov dwh,cano	Cov dwh,hay	Cov oats,hay	Cov barl,flax
Coef.		-22.67	-13.09	30.83*	6.33	-5.78	16.45	-2.79	-4.23	-1.04
Std. Err.		16.78	14.89	17.81	8.87	11.31	14.80	13.73	9.70	11.35
	barl acre	Cov swh,barl	Cov dwh,barl	Cov oats,barl	Cov barl,rye	Cov barl,peas	Cov barl,flax	Cov barl,cano	Cov barl,hay	
Coef.		2.69	3.21	5.98	-18.71	15.62	-2.12	-29.46	-54.60**	
Std. Err.		18.12	15.79	13.22	12.85	15.33	23.42	22.88	28.41	
	rye acre	Cov swh,peas	Cov dwh,flax	Cov oats,peas	Cov barl,peas	Cov rye,peas	Cov rye,cano			
Coef.		5.25	-2.45	-3.59**	-0.19	0.62	-1.80			
Std. Err.		3.51	3.13	1.55	4.03	2.80	3.97			
	peas acre	Cov swh,peas	Cov swh,cano	Cov swh,hay	Cov dwh,peas	Cov rye,peas	Cov rye,hay			
Coef.		-7.65*	3.45	8.73	-3.54	6.92**	-8.09			
Std. Err.		4.77	6.08	11.05	3.79	3.13	8.76			
	flax acre	Cov swh,dwh	Cov swh,oats	Cov dwh,oats	Cov oats,barl	Cov oats,flax	Cov oats,cano	Cov barl,cano	Cov peas,flax	Cov peas,cano
Coef.		-12.29	31.30**	6.73	-31.80**	-18.98**	16.27**	29.17**	18.38**	-18.41**
Std. Err.		8.99	8.79	6.41	10.41	9.86	7.94	12.25	7.66	6.47
	cano acre	Cov swh,dwh	Cov swh,oats	Cov swh,rye	Cov swh,peas	Cov swh,hay	Cov dwh,barl	Cov dwh,cano	Cov oats,barl	Cov oats,rye
Coef.		130.28**	125.64**	-57.68**	-95.61**	129.41**	-263.06**	58.37**	-56.34	-64.43**
Std. Err.		45.00	37.65	21.14	18.15	39.62	83.03	21.34	27.14	23.12
	hay acre	Cov swh,cano	Cov swh,cano	Cov dwh,peas	Cov dwh,flax	Cov dwh,cano	Cov dwh,hay	Covoats,peas	Cov barl,rye	Cov barl,flax
Coef.		1.78	17.69**	5.51	-6.16	16.68**	-7.34	3.95	6.11	-14.24
Std. Err.		5.89	9.11	5.04	7.65	7.83	7.44	2.90	5.58	10.53

Table E2: Continued

	swh acre	Cov barl,rye	Cov barl,flax	Cov barl,hay	Cov rye,peas	Cov rye,cano	Cov peas,flax	Cov peas,cano	Cov peas,hay	Cov flax,hay
Coef.		-145.58**	42.24	236.13**	-68.18**	144.52**	-42.08*	54.60**	106.72**	-100.00**
Std. Err.		43.46	37.51	63.50	19.35	35.19	25.20	14.06	26.36	41.20
	dwh acre	Cov dwh,hay	Cov oats,flax	Cov oats,peas	Cov barl,peas	Cov barl,flax	Cov barl,cano	Cov rye,peas	Cov rye,flax	Cov rye,cano
Coef.		56.54*	-13.36	-24.83	-32.46	29.51	16.91	37.42**	-25.74	-48.64
Std. Err.		32.82	11.49	19.02	32.55	56.61	33.91	17.09	27.31	30.99
	oats acre	Cov barl,hay	Cov rye,peas	Cov rye,flax	Cov rye,cano	Cov peas,flax	Cov peas,cano	Cov peas,hay	Cov flax,hay	Cov cano,hay
Coef.		-16.81	3.69	2.12	-14.89	6.68	-5.08	-21.53*	22.53	14.40*
Std. Err.		24.63	7.32	11.35	15.96	8.21	5.27	11.94	17.92	8.12
	barl acre									
Coef.										
Std. Err.										
	rye acre									
Coef.										
Std. Err.										
	peas acre									
Coef.										
Std. Err.										
	flax acre	Cov flax,cano								
Coef.		-7.75								
Std. Err.		5.81								
	cano acre	Cov oats,peas	Cov oats,flax	Cov oats,cano	Cov barl,rye	Cov barl,peas	Cov barl,flax	Cov barl,hay	Cov flax,hay	
Coef.		-19.55**	-111.25**	27.13	111.04**	95.47**	118.59**	-214.77**	40.51	
Std. Err.		8.21	28.82	13.05	40.61	27.14	50.12	51.95	24.79	
	hay acre	Cov rye,flax	Cov rye,cano	Cov peas,flax	Cov peas,cano	Cov peas,hay	Cov cano,hay			
Coef.		-1.26	-3.08	3.55	-9.67**	-3.61	-2.14			
Std. Err.		6.08	5.40	7.02	4.87	6.69	4.73			

Notes: * is significant at 10 percent and ** is significant at 5 percent. Cov swh,canola= Covariance between spring wheat and canola profits; barl=barley; cano=canola.

Appendix F.

Table F1: Simulation of Acreage Changes due to NISA and CAIS

	Spring wheat	Spring wheat	Barley	Rye	Peas	Canola
MN (avg 1991-2002 in acre)						
Acreage planted	3878979.962	3878979.962	1218804	77672	168863.8	2132517
NISA wealth effect	7567.566575		-3373.7	1530.424		
NISA insurance effect		351347.5948			25631.07	-244377
SK (avg 1991-2002 in acre)						
Acreage planted	12394099.38	12394099.38	4307317	236257.8	1472928	5171563
NISA wealth effect	10451.20664		-4659.25	2113.596		
NISA insurance effect		650935.4039			47486.23	-452753
AB (avg 1991-2002 in acre)						
Acreage planted	6103573.108	6103573.108	5213515	139168.2	441485	3673997
NISA wealth effect	11645.02244		-5191.47	2355.027		
NISA insurance effect		666996.0041			48657.87	-463923
MN (avg 2003-2006 in acre)						
Acreage planted	2903567.333		935471.3	79945.67	120289	2536772
CAIS wealth effect	13778.82499		-6142.74	2786.556		
CAIS insurance effect		392721.944			28649.36	-273154
SK (avg 2003-2006 in acre)						
Acreage planted	9477554.667	9477554.667	4372312	274828.7	2565754	6239714
CAIS wealth effect	54010.78315		-24078.6	10922.85		
CAIS insurance effect		957557.3936			69854.54	-666021
AB (avg 2003-2006 in acre)						
Acreage planted	5652759.667	5652759.667	4496388	193236.3	613795	4121030
CAIS wealth effect	40693.35721		-18141.5	8229.606		
CAIS insurance effect		462560.7802			33744.16	-321730

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