Transfer efficiency analysis of margin based programs

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Abstract: AgriStability, Canada's major farm support and business risk management (BRM) program, has been in place since 2007. As with most agricultural insurance programs, AgriStability creates opposing incentives where moral hazard and misallocation effects discourage production while the risk reduction effects encourage production. We investigate the relative size of these effects to determine both the degree to which production is distorted and the percent of government transfer that remains with the producer. Our results indicate mild but differential effects across crops. We find roughly 40 percent of program payments remain with primary producers. These findings are of particular interest because of their WTO implications.

JEL codes: Q18, Q13

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Introduction

Canada has a long history of agricultural safety net programs that act as a floor for variables that have been targeted for stabilization. The programs have evolved from the price based mandatory commodity-specific program, *Agriculture Stabilization Act* (1958-75), to a voluntary mechanism where the program trigger was based on aggregate net cash flow for a basket of seven prairie crops under the *Western Grains Stabilization Act* (1975-90), reverting back to a voluntary commodity-specific revenue based insurance program *Gross Revenue Insurance Program* (1990-95) and finally morphing into to a voluntary individual margin approach based on net income calculation covering most commodities -- *Net Income Stabilization Account* (1990-2002), AIDA/CFIP (1998-2002), *Canadian Agricultural Income Stabilization (CAIS) Program* (2002-06), and *AgriStability* (2007-present).

There has been deliberate action to move away from payments that are specific to a commodity to a margin that represents a measure of overall whole farm profitability.

Between 2004 and 2009 business risk management payments (BRM) averaged $1.2 billion or 50 percent of federal program expenditures. Average federal expenditures on *CAIS, AgriStability and AgriInvest* were $777 million with provincial expenditures on these programs averaging $646 million. The addition of another $822 million in *ad hoc* BRM programs (e.g. CAIS inventory adjustment, cost of production payments, AgriInvest Kickstart and other ad hoc payments) increased the share of BRM spending to 84 percent of federal agricultural program spending. So *AgriStability* comprises a significant portion of spending by both federal and provincial agriculture departments.

Despite the long tradition of these programs there has been little academic literature examining their transfer efficiency or their effect on input decisions. We define transfer

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1 AgriStability is accompanied by AgriInvest, AgriRecovery, and Production Insurance. AgriInvest is a restricted savings program similar to NISA whereas AgriRecovery is a disaster assistance program. Production Insurance is a commodity specific yield shortfall program.

2 Ironically, this type of risk management program encourages less diversification in production.
efficiency as the change in producer surplus divided by the change in government expenditures less the change in consumer surplus. Notable exceptions are Turvey et al (1995), Mussell and Martin (2005), Schaufele, Unterschultz and Nilsson (2010), and Turvey (2011). Turvey et al (1995) examined the transfer efficiency of NISA type programs but did not address the different incentives with respect to input choice. Mussell and Martin (2005) using farm-level data examined how effectively CAIS stabilized incomes. Schaufele et al (2010) used a stochastic simulation model and capital budgeting approach to evaluate AgriStability for cow-calf producers in terms of its ability to stabilize and increase certainty equivalent wealth. Finally, Turvey (2011) examined the impact of whole farm insurance schemes on farm portfolio choice.

Given the significance of risk management programs in Canadian agricultural policy, particularly with respect to allocated monies, there has been surprisingly little literature on their effect on transfer efficiency or input decisions. More work has been done in this regard with respect to the US crop insurance program. For example, Quiggin, Karagiannis, and Stanton (1993), Horowitz and Lichtenberg (1993), Smith and Goodwin (1996), and Babcock and Hennessy (1996) have looked at input decisions under yield and revenue insurance.

Given that Canada has committed to introducing a new agriculture policy framework (Growing Forward II) with risk management programs that will in all likelihood be similar in structure to the current suite of risk management programs, it is important to look at the transfer efficiency of AgriStability and the effect of AgriStability on input decisions. The objectives of this manuscript are: (i) develop a conceptual model of how AgriStability affects input decisions; and (ii) examine program impacts on factor and product markets. The latter is accomplished by incorporating the decision rules from the conceptual model into an equilibrium displacement market model and simulating. The impacts considered are: (i) how input decisions change; (ii) the effect of those changes on production; (iii) the effect of these changes on the welfare of farmers, landowners, taxpayers, consumers, and input suppliers; and (iv) the transfer efficiency of
AgriStability in terms of the share of the benefits that remain with the producers’. We do not investigate possible changes in industry participation or additional land being brought into agricultural production (i.e. extensive margin).^4

**AgriStability**

AgriStability is a producer deficiency payment equal to a portion of the difference between 85 percent of the historic reference margin and the current year margin. The historic reference margin is an average of the previous five years production margins with the high and low margins excluded. Production margins calculate allowable incomes minus allowable expenses with adjustments for changes in receivables, payables, and inventory. The margin is intended to reflect only revenues and expenses that are directly related to production. For example, the purchase and subsequent resale of a product would not be considered allowable income. By design, the program excludes these incomes and expenses thus reducing producer incentives to engage in moral hazard activities which could inappropriately triggering payments by creating or shifting incomes and/or expenses over time. Excluded expenses include land rental, machinery, equipment and buildings, salaries for family members, and many administrative expenses (telephone, office expenses, legal and accounting). **However, given this is a margin-based program (i.e. not all expenses are excluded) some moral hazard incentives do remain.**

Government payments under AgriStability are determined according to the magnitude of the loss, relative to the historical margin, experienced.^5 Losses between 0-15 percent below the reference margin are not covered but are eligible for saving account withdrawals under the companion program AgriInvest. AgriStability payments occur in two layers (see figure 1) where losses between 15-30 percent correspond to the stabilization layer (tier 2 below) and losses of

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^4 An extensive margin involves movements of land in and out of agricultural production. Given that we do not take into account extensive margins our production enhancing effects will necessarily be biased downward. However, given the complexity of the program’s off-setting effects it is unlikely that significant volumes of land will enter or exit agriculture.

^5 The producer premium for AgriStability is set at 0.1 percent of total liability. That is, total liability of $1.0 million would result in a producer premium of $1,000.
greater than 30 percent correspond to the disaster layer (tier 1 below). The larger the income loss, the larger is the share of government payment. Implicit in this approach is that the producer incurs a level of coinsurance inversely proportional to the loss.

**Figure 1:** *AgriStability Payments by Level of Program Margin Loss*

![Figure 1: AgriStability Payments by Level of Program Margin Loss](image)

**Economic Model**

We model the producer’s response to *AgriStability* through his/her choice of inputs within an expected utility framework. The expected utility for a representative producer is as follows:

\[
\text{Max } EU(\pi)_{\omega} = \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U(\pi(\omega) + 0.8 \cdot (RM - PM(\omega))) \cdot f(\omega) d\omega \\
+ \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U(\pi(\omega) + 0.7 \cdot (RM - PM(\omega))) \cdot f(\omega) d\omega + \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U(\pi(\omega)) \cdot f(\omega) d\omega
\]

(1)

Where \( \omega \) is a composite stochastic variable that reflects the random states of nature and stochastic market factors that affect output and commodity prices. Profits (\( \pi \)) are a stochastic function of revenues less expenses, \( \pi(\omega) = \sum_{i=1}^{3} \left[ R(x, \omega)_i - \sum_{j=1}^{n} V_j \cdot X_{ij} \right] \). Revenues are obtained from the sales of three outputs and are stochastic, while input prices (\( V_j \)) are fixed and exogenous and input quantities (\( X_{ij} \)) are fixed but endogenous. The number of eligible inputs (\( m \)
is necessarily less than the number of total inputs \( n \) and thus the production margin is defined as:

\[
PM(\omega) = \sum_{i-1}^{3} [R(x, \omega)_i - \sum_{j=1}^{m} V_j \cdot X_{i,j}^{eligible}] \cdot RM
\]

where \( RM \) is the program reference margin and is fixed and exogenous. The three domains of integration partition the space of \( \omega \) and represents a one-to-one mapping into the realized production margin space thereby partitioning that space into the three regions of the AgriStability program (disaster layer, stabilization layer, and no payment).

The producer maximizes the expected utility of profits by choosing optimal input levels. The resulting first order conditions are derived in the appendix and after some manipulation the producer’s decision for an eligible input, say \( X_j \) is:

\[
\left( \sum_{i=1}^{3} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \cdot \frac{EVMP(i)}{EVMP_j} \right) \cdot EVMP = V_j^{eligible} \cdot \left[1 - \sum_{i=1}^{2} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \right] + \lambda \cdot (1 - \Delta) \cdot \left[ \text{cov}(R, VMP_j) + \text{cov}(G, VMP_j) \right]
\]

where \( i = \{1, 2, 3\} \) refers to the three states of nature as defined by the program parameters of AgriStability and the corresponding program parameters \( \phi(1) = 0.8, \phi(2) = 0.7, \) and \( \phi(3) = 0 \). \( V_j \), is the input price, \( \lambda \) is the Arrow-Pratt absolute risk aversion coefficient \((-EU''/EU')\), \( 1 - \Delta \) is equal to \( (1 - 0.8 \cdot EMU(1)/EMU - 0.7 \cdot EMU(2)/EMU) \), \( EMU \) is expected marginal utility and the bracketed numbers refer to the applicable state of nature, \( EVMP \) is the expected value of the marginal product and again the bracketed numbers refer to the applicable state of nature, the covariances are between value of the marginal product of input \( j \) and revenues in the first case and government spending, \( G \), in the later case.

This decision rule is a variant of the conventional input rule where the expected value of the marginal product \( (EVMP_j) \) is equated to the input price \( V_j \) plus a risk premium. The AgriStability program adjusts the decision rules in three important ways: a moral hazard effect, an input price reduction effect, and a risk reduction effect.
The moral hazard effect is the bracketed effect on the left hand side of equation (2). This adjustment factor is a share weighted parameter. The numerator of the shares is the product of the expected marginal utility times the expected value of the marginal product of the input, for the domain of the integral in equation 1 under consideration. The denominator is the product of the same terms but for the entire integral from \( \omega_{\min} \) to \( \omega_{\max} \). In the absence of the program the sum of these shares for each domain is equal to one and the expected value of the marginal product is equal to the undistorted level. The program introduces parameters of \( \phi(1) = 0.8 \) and \( \phi(2) = 0.7 \) which reduce the adjustment factor to a value of less than 1. As a result it is less profitable to purchase inputs and input use declines. This is consistent with a moral hazard effect where because the producer is guaranteed a return he/she will purchase fewer inputs because the insurance guarantee reduces the marginal return from an additional unit of input (Ramaswami 1993) and this effect holds regardless of whether the input is risk reducing or increasing.

The input price reduction effect is represented by the first bracketed term on the right hand side of equation (2). This term is \( (1 - 0.3 \cdot EMU(1)/EMU - 0.2 \cdot EMU(2)/EMU) \) where the share weights on the parameters sum to less than unity because the domain with no government payments is excluded. Therefore the entire term will always be less than one and the effective price paid for eligible inputs will decline thereby increasing the demand for these inputs.

The second term of the right hand side of equation (2) is a risk premium, where the coefficient of absolute risk aversion is multiplied by the sum of two covariances. In the absence of a program the risk premium is \( \lambda \cdot \text{cov}(R,VMP) \). The term \( (1 - \Delta) \) is equal to \( (1 - 0.7 \cdot EMU(1)/EMU - 0.8 \cdot EMU(2)/EMU) \) and is less than unity. This term reduces the base risk premium. In addition a negative covariance between government expenditure \( (G) \) and the value of the marginal product \( \text{cov}(G,VMP) \) further reduces the risk premium and increases the demand for the input under consideration.
The first order condition with respect to the non-eligible input is:

\[
\sum_{i=1}^{n} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \cdot \frac{EVMP_i}{EVMP_j} \cdot EVMP = V_{j\text{non-eligible}} + \lambda \cdot (1 - \Delta) \cdot \left[ \text{cov}(R, VMP_j) + \text{cov}(G, VMP_j) \right]
\]

This decision rule differs from equation (2) in that the ineligible input does not enter the program margin and as a result the effective price of the factor input \( V_j \) remains unaltered by the program. The result of the difference between equations (2) and (3) is that the price of eligible inputs falls relative to the price of non-eligible inputs and the usage of eligible inputs expands at the expense of non-eligible inputs. This change in the relative mix of inputs results in a misallocation effect that reduces output supplies.

The overall effect on input use depends on the combined moral hazard, input price reduction/misallocation and risk reduction effects. It is not possible to determine the impact on each input in a multiple input setting, and the effect on the output of each product will depend on the combined effects of all of their inputs. For these reasons it is necessary to build a simulation model to simultaneously account for these effects across all inputs, outputs, and product market adjustments. This requires a model that is capable of accounting for adjustments in both factor and product markets.

**Modelling Strategy**

Before we can proceed with a market level simulation model it is necessary to develop parameters for equations (2) and (3). The method used develops a separate stochastic approach to conduct Monte Carlo simulations which generate representative production margins based on joint distributions of yields and prices for wheat, coarse grains and oilseeds. This information can then be applied, together with the rules of AgriStability, to determine the expected utility of profits for a representative producer.
By the small country assumption, prices and yields are assumed to be independent. Expenses for the production margin are assumed to be pre-determined and therefore non-stochastic. The joint distributions for prices and yields are multivariate normal distributions estimated using annual price and yield data for the period 1986-2010. Given these distributions we conduct 1000 simulations of a simple model of the program margin.

Given the distribution of the producer returns, the expected utility of profits is determined using a negative exponential utility function. The coefficient of absolute risk aversion can be obtained from an estimate of the coefficient of relative risk aversion and the relationship between the two measures where the absolute coefficient of risk aversion is equal to the relative risk aversion coefficient divided by expected profits. According to Anderson and Dillon (1992), relative risk aversion can be measured on a scale of 0.5 to 4 where 0.5 is hardly risk averse and 4 is considered as extremely risk averse. Under this classification system a coefficient of 2 is described as “rather risk averse” and for this reason forms the basis of the calculation of the coefficient of absolute risk aversion used in this manuscript. A CES production function is used to determine the marginal product for each input. Since outputs and product prices are stochastic, the expected value of the marginal product is also stochastic and is a function of the output of the simulation.

We calculate expected marginal utilities, expected prices, and expected marginal products, for each input, based on the results of the stochastic simulation. The parameters of the moral hazard, input price reduction and risk reduction effects are determined according to the definitions from equations (2) and (3) and the expected value of marginal products and expected marginal utilities for each of the three domains of the producer’s optimization problem. The expected values for first two domains (tiers 2 and 1) depend on the program parameters and the results are calibrated so that government payments $G$ are roughly equal to $AgriStability$ payments in 2009. It is assumed the program parameters do not affect the stochastic variables but only the returns received by the representative producers.
Simulation Models

The preceding analysis has been concerned with a representative producer but we are interested in the implications at the aggregate market level while accounting for product and factor market adjustments. A basic framework that allows input substitution in production was originally used by Hicks (1932), extended to agriculture by Floyd (1965) and popularized by Gardner (1987). The behaviour of the representative producer, described above, is now assumed to hold at the aggregate level for all producers. Profit maximization by the representative producer is accomplished by equating the expected value of the marginal product to the input price plus a risk premium. Equations (2) and (3) adjust input decision rules to account for the effects of AgriStability. Although the market simulation model is not solved stochastically, the input decision rules introduce expected values for marginal utility, the value of the marginal product, and associated risk premium into the producers input decision rules. These aspects are calibrated into the base model. The introduction of AgriStability reduces the risk premium, lowers the price of inputs for eligible inputs, and adjusts the value of the marginal product for the moral hazard effect.

The calibration of the market model follows Dewbre and Short (2002) and approaches developed by the OECD Secretariat including OECD (2001), Dewbre, Antón, and Thompson (2001), and Antón and Le Mouël (2004). The model covers two regions – Canada and the rest of the world- with three outputs (wheat, coarse grains, and oilseeds) and 8 inputs (land, farmer owned, chemicals, fertilizers, energy, hired labour, other purchased and machinery repair). The structure of the model consists of a system of equations that account for input supplies and demands, non-joint production functions for each of the final products, commodity demands for these outputs, market clearing conditions and zero profit conditions (Gardner 1987). This system of equations is then totally differentiated so that the behavioural equations employ variables in rates of change and that the parameters are elasticities. This class of models is described as equilibrium displacement and is solved in terms of percentage changes and measures the effects
of moving to a new equilibrium in response to changes in exogenous variables or policy parameters. These models are exponentially complex in terms of the number of inputs and/or outputs.

The model’s equations are presented in table 1 and its parameters are described below. All variables presented in lower case are defined as proportional rates of change and all variables in capital letters represent levels. The model is calibrated to base prices and quantities in the year 2009. Percentage changes are applied to the base levels to determine the new levels for each variable.

Table 1: Market model

<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4) $q_i^d = \sum_{j=1}^{3} \eta_{ij} \cdot p_j^d$</td>
<td>Domestic consumption</td>
</tr>
<tr>
<td>(5) $P_i^d \cdot Q_i^r = \sum_{j=1}^{10} V_{ji}^d \cdot X_{ji}^d$</td>
<td>Zero profits</td>
</tr>
<tr>
<td>(6) $x_{ji} = \sum_{j=1}^{10} c_{ji} \cdot \sigma_{ji} \cdot v_j^d + q_i^r$</td>
<td>Input demands</td>
</tr>
<tr>
<td>(7) $x_j^s = e_j \cdot v_j^s$</td>
<td>Non-land input supply</td>
</tr>
<tr>
<td>(8) $x_{la_i}^s = \sum_{j=1}^{e_j} \cdot v_{la_j}^s$</td>
<td>Crop land supply</td>
</tr>
<tr>
<td>(9) $X_{ji}^{la} = X_{ji}^d$</td>
<td>Market clearing non-land farm inputs</td>
</tr>
<tr>
<td>(10) $X_{ji}^d = X_{ji}^{p} + X_{ji}^{e} + X_{ji}^{w}$</td>
<td>Market clearing purchased inputs</td>
</tr>
<tr>
<td>(11) $X_{la_i}^d = X_{la_i}^d$</td>
<td>Market clearing land</td>
</tr>
<tr>
<td>(12) $Q_i^r = Q_i^r + Q_i^X$</td>
<td>Market clearing domestic</td>
</tr>
<tr>
<td>(13) $Q_i^X = Q_{ROW}^d - Q_{ROW}^s$</td>
<td>Market clearing world</td>
</tr>
</tbody>
</table>

Demands (equation 4) for each crop are calculated as a percentage change from base levels with equations that are linear sums of the product of demand elasticities and percentage changes in own and cross prices. A zero profit condition (equation 5) for each crop equates revenues with total expenditures for all eight factors of production and the equation is solved in terms of levels. The crop supply side of the model is determined by combining factor supplies and factor demands that are derived from a CES production function. As a result the factor demands (equation 6) are calculated as rates of change from base levels that are a function of the
sum of the products of cost shares of each input multiplied by its elasticity of substitution times
the percentage change in the factor price plus the rate of change in output levels. Factor supplies
(equation 7 for non-land inputs and equation 8 for crop land supplies) are calculated as
percentage changes which are a function of the elasticity of supply and the percentage change in
the own factor price.

Two factors of production, land and farmer owned capital (including household labour
and management) are specific to each crop and each have a separate supply function and separate
market clearing conditions (equations 9 and 11). Other factors of production (hired labour,
chemicals, energy, fertilizer, machinery and equipment repair, and other purchased inputs) which
are not specific to a crop and have a shared supply are allocated to factor demands by each crop
through market clearings conditions (equation 10). Equations (12) and (13) are market clearing
conditions for the domestic and world markets for each of the crops.

Producers and consumers in the rest of the world face the world price which is the market
clearing price for equation (12). The model is calibrated so that the consumer and producer world
prices of each grain are equal. The introduction of AgriStability introduces a moral hazard
adjustment to the EVMP, in equations 2 and 3. This affect is introduced into the model by
adjusting each crop’s producer price as suggested above. The remaining effects of the program
are introduced by adjusting the difference between the supply and demand prices of inputs. The
input price reduction effect is introduced as a wedge between the supply price and the demand
price for eligible inputs but not for non-eligible inputs. The impact of the risk reduction effect is
introduced through a further increase in the wedge between the supply and demand price for all
inputs (effectively reducing demand prices).

The model described in table 1 depends on a number of parameters including: elasticities
of substitution between factors, factor shares, elasticities of factor supply, domestic elasticities of

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6 The market clearing conditions are treated as levels and all percentage changes are added back to baseline
levels so that the new levels can be directly incorporated in the market clearing conditions.
product demand (own and cross price) and supply and demand elasticities for each product in the rest of the world. These parameters were not estimated but were obtained from prior studies. Most of the parameters, employed in this manuscript, are based on OECD (2001) that in turn were based on an exhaustive survey by Abler (2001). Abler (2001) showed that there is significant consensus with respect to the potential magnitude of substitution elasticities. The estimates used are based on the OECD (2001) estimates and are shown in appendix table 1.

The factor shares are described in appendix table 2 and were obtained from cost estimates for partial budgets for Alberta (Alberta Agriculture and Rural Development), Saskatchewan (Schoney), Manitoba (MAFRI) and Ontario (OMAFRA) for wheat, barley, corn, canola and soybeans. Cost estimates were averaged across provinces and aggregated across coarse grains and oilseeds. Factor shares are central to the model, in part to derive the input demand parameters, but also to obtain the value and volume of each purchased input. The method of obtaining inputs starts with a measure of total revenue for each crop. The zero profit assumption assures that total revenue equal expenses. Total expenses for each crop are then shared out to each of the inputs. In the case of land, actual areas are available, so given land expenditures land prices can be determined. In the case of other inputs, price or volumes are not available and thus only relative volumes are recovered.

Abler’s (2001) survey of elasticities of factor supply is less complete in that he found less information to draw on and more variability between the studies. Following OECD (2001) supply elasticities for farmer owned inputs ranged from 0.2 to 0.6 and purchased input elasticities ranged from 1 to 5. This manuscript employs intermediate values 0.4 for farmer owned land and capital and 2.5 for purchased inputs. Sensitivity analysis is conducted to account for parameter uncertainty. Own and cross price elasticities are shown in appendix table 3 and were obtained from the Aglink module for Canada, which were originally obtained from AAFC’s FARM model. Prices and quantities in the model were obtained from the OECD PSE database for 2009. These basic data are used to calibrate the model for that year.
In 2009 the OECD PSE calculation for payments based on overall farming income was $1.6 billion with $1.1 billion in AgriStability payments (39 million for tier 1 (stabilization) payments and $1.06 billion in tier 2 (disaster) payments). Public estimates of the share of this expenditure attributable to grains and oilseeds are not provided. However a crude estimate is in the order of $400-500 million. By comparison government expenditures on production insurance for grains and oilseeds in 2009 was $673 million.

Results

Table 2 presents the impact of introducing AgriStability relative to a baseline with no program in place. This exercise is illustrative and is not intended to exactly replicate the markets. One limitation involves the aggregation from the individual producer to the market. This study uses aggregate market level prices and yields to produce a stochastic simulation of the program’s payment mechanism, calibrated to 2009 grains and oilseeds data, with measures of variability based on the previous two decades of data for prices and yields. Given that we do not have access to program records and accurate disaggregated expenditures on the program, we calculated representative stochastic program margins and a reference margin that resulted in $700 million in program spending. This is a conservative approach that reflects the higher spending on grains and oilseeds in the period prior to 2006 and may accommodate larger than recent program impacts. This information was used to create wedges between the prices paid by producers for factors of production and those received by input suppliers. This adjusts for the lower risk premium, lowers the price of inputs for eligible inputs, and adjusts the value of the marginal product for the moral hazard effect.

Table 2 Program Implementation
First, consider the factor market where the initial incidence for the program is introduced. *AgriStability* creates a differential effect between eligible and non-eligible inputs. As a result of the reduction in the risk premium and the decline in the effective price of eligible inputs, the average price for purchased inputs declines by 13-15 percent inducing extra input usage. Non-allowable inputs include: land, farmer owned capital, interest expenses, and machinery and equipment. Farmer-owned capital is a residual of revenues after subtracting land values and the expenses for all purchased inputs, so effectively this input includes a return to the farmer’s labour and management. The average supply price of farmer owned capital and land is driven up by the program by 3 percent and 10 percent respectively, while the demand price for machinery expenses and interest costs decline in the order of 10 percent.
As a result of these changes in factor utilization, AgriStability increases the production of wheat by 1.5 percent, coarse grains by almost 5 percent, and oilseeds less than 1 percent. The differential impacts are a result of different factor intensities for each of the crops. Land use increases by 0.3 percent for wheat, by 1.7 percent for coarse grains and declines by 1.7 percent for oilseeds. These changes reflect the substitution possibilities associated with a variable factor proportions technology -- other inputs are substituted for land and output increases with minor changes in land use.

The increase in crop production, and Canada’s relatively small share of international markets, results in no measureable change in world prices. Consumers are beneficiaries with declines in crop prices such that consumer surplus increases by only $4 million. Producer surplus increases by $272 which reflects the increase in factor incomes for land and farmer owned capital. Most of this increase occurs through an increase in factor prices for farmer owned capital (4 percent for wheat based inputs; 9 percent for inputs associated with coarse grains; and -3.5 percent for oilseeds) and land prices (11 percent for wheat; 14 percent for coarse grains; and 7 percent for oilseed land).

Transfer efficiency is measured as the change in producer surplus relative to the increase in government spending. Farm households capture roughly 39 percent of the additional $700 million in program spending and thus AgriStability has a transfer efficiency of 39 percent.

Sensitivity Analysis

The above results are contingent on our choice of parameters and so we conduct a standard sensitivity analysis to determine how robust the results are. The parameters that are known with the least certainty are the elasticities of factor supply. In order to account
for this uncertainty supply elasticities are drawn from uniform distributions using Monte Carlo simulation techniques. The bounds on the uniform distribution were taken from minimum and maximum values for own price elasticities obtained from Abler (2001 Table A2.10 page 81). The original model was calibrated with supply elasticity of 0.4 for farmer owned inputs and 2.5 for all purchased inputs. The bounds for supply elasticities for farmer owned inputs ranged from to 0.2 to 0.6 while the bounds for elasticities of supply for purchased inputs ranges from 1 to 5.

Figure 2 shows the impacts for each of the three crops. In each case despite the broad range of supply elasticities the effects on the percentage change in supply fell within a narrow band of impacts. Responses fell between -0.5 and 3 percent for wheat, between 3 and 5.5 percent for coarse grains, and between -1 and 3 percent for oilseeds. As expected, the larger the supply elasticities the larger is the supply response.
Figure 2  Distributions of Output Changes

Wheat

% change in output

Coarse Grains

% change in output

Oilseeds

% change in output

kernem = epanechnikov, bandwidth = 0.0016

kernem = epanechnikov, bandwidth = 0.0012

kernem = epanechnikov, bandwidth = 0.0019
We also considered the sensitivity of the transfer efficiency estimate of 39 percent.

Again the sensitivity analysis is driven by changes in the elasticity of factor supply for the ranges discussed above. The results are shown in figure 3.

**Figure 3  Distribution of Transfer Efficiency**

![Distribution of Transfer Efficiency](image.png)

Again most of the mass of the distribution is between 0.32 and 0.43 with larger elasticities resulting in larger output changes and lower rates of transfer efficiency. In this comparison larger supply elasticities can be thought of as reflecting longer time periods where all inputs are allowed to fully adjust.

**Conclusions**

The objective of this study was to develop a quantitative model to estimate quantity and price impacts and agent specific welfare effects of Canadian margin based safety net programs. The fact that these programs are based on a net margin adds to the complexity of the model, given the multitude of factors that determine the farm’s bottom line and how the program is implemented.
A program can be evaluated from an international perspective (WTO implications) in terms of how it affects the level of production and ultimately exports. A program can also be evaluated from a domestic perspective in terms of how efficient it is in both allocating resources and transferring wealth to the intended recipients. The presence of a moral hazard effect and the differential treatment of eligible versus non-eligible expenses results in inefficiencies and downward pressure on production. From the perspective of WTO disciplines on domestic supply, *AgriStability* does not neatly fit into the non-disciplined category of support (Annex 2 of the Agreement on Agriculture). However, given the program does not appear to induce a significant amount of production it should be preferred to other forms of support that more unambiguously induce production. However, from the perspective of efficient domestic policy, some concerns can be raised given the low transfer efficiency.

The conflicting effects of *AgriStability* and the complexities of the program make it difficult to model. The approach used in this manuscript necessarily abstracts from some of these complexities – other forms of risk affecting the program margin, greater commodity coverage, and the exclusion of the possibility of joint production and any interdependence of inputs. Despite this, the analysis does provide robust insight in several areas. First, no matter how much additional complexity is added to the model the prediction that the program has only a minor impact on production should hold. In fact, additional complexity would allow more trade-offs and thus more off-setting effects with respect to production. Second, increasing the complexity of the model is unlikely to yield higher levels of transfer efficiency. Again, more trade-offs producer greater off-setting
effects leading to increased leakages of government money away from farm household income.

Improvement in producer welfare come primarily in the form of increased land rents and does not significantly improve the returns to other farm owned inputs. These gains cannot be viewed as a source of improving the long-term well-being of farm households because they are capitalized into the selling price of land which will disadvantage renters and future owners. Given that an increasing share of land is rented, benefits of government programs will not be captured by primary agricultural producers.
References


OECD (2010), *Producer and Consumer Support Estimates database*


Technical Appendix: Derivation of equations (2) and (3)

Assume the farmer’s objective is to maximize the expected utility of profits by choosing eligible and non-eligible inputs. Following the set-up described in the main text, the objective function is:

\[
\text{Max } EU(\pi) = \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U(\pi(\omega)) + 0.8 \cdot (RM - PM(\omega)) \cdot f(\omega) d\omega + \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U(\pi(\omega)) \cdot f(\omega) d\omega
\]

(A1)

The first order conditions with respect to eligible inputs are:

\[
\begin{align*}
\frac{EU(\pi)}{x^*_j} &= (1 - \phi_1) \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(1) \cdot R(1) x^*_j \cdot f(\omega) d\omega + (1 - \phi_2) \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(2) \cdot R(2) x^*_j \cdot f(\omega) d\omega \\
&\quad + \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(3) \cdot R(3) x^*_j \cdot f(\omega) d\omega = \\
&\quad \left[ (1 - \phi_1) \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(1) \cdot f(\omega) d\omega + (1 - \phi_2) \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(2) \cdot f(\omega) d\omega + \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(3) \cdot f(\omega) d\omega \right] \cdot V^e_j
\end{align*}
\]

(A2)

The notation is the same as in the main text. Derivatives of the utility function, with respect to revenues \( R \), are shown with a prime and derivatives of the revenue function \( R \), with respect to \( x_j \) are denoted with a subscript. The optimization takes place over the three tiers of the program (see figure 1), so the various derivatives are identified, by tier, with a bracketed number. Equation (A2) can be re-written in terms of expectations

\[
\begin{align*}
\frac{EU(\pi)}{x^*_j} &= (1 - \phi_1)EU'(1) \cdot ER(1) x^*_j + (1 - \phi_1) \text{cov}\left(U', R(1) x^*_j \right) + (1 - \phi_2)EU'(2) \cdot ER(2) x^*_j + (1 - \phi_2) \text{cov}\left(U', R(2) x^*_j \right) \\
&\quad + EU'(3) \cdot ER(3) x^*_j + \text{cov}\left(U', R(3) x^*_j \right) = \left( EU' - \phi_1 \cdot EU'(1) - \phi_2 \cdot EU'(2) \right) \cdot V^e_j
\end{align*}
\]

(A3)

By the application of the Stein-Rubenstein covariance operator (Rubenstein 1973), \( \text{cov}(U,R) \) can be written as \( EU'' \cdot \text{cov}(\pi,R) \). Divide both sides of equation (A3) by \( EU' \), multiply and divide by \( ER x^*_j \) and \( EU'(i) \) and substitute for the covariance operator.

\[
\begin{align*}
\frac{EU(\pi)}{x^*_j} &= (1 - \phi_1) \frac{EU'(1)}{EU'} \cdot \frac{ER(1) x^*_j}{ER x^*_j} + (1 - \phi_1) \frac{EU'(1)}{EU'} \cdot \frac{EU''(1)}{EU'(1)} \text{cov}\left(\pi, R(1) x^*_j \right) + \\
&\quad (1 - \phi_2) \frac{EU'(2)}{EU'} \cdot \frac{ER(2) x^*_j}{ER x^*_j} + (1 - \phi_2) \frac{EU'(2)}{EU'} \cdot \frac{EU''(2)}{EU'(2)} \text{cov}\left(\pi, R(2) x^*_j \right) + \\
&\quad + (1 - \phi_2) \frac{EU'(3)}{EU'} \cdot \frac{ER(3) x^*_j}{ER x^*_j} + (1 - \phi_2) \frac{EU'(3)}{EU'} \cdot \frac{EU''(3)}{EU'(3)} \text{cov}\left(\pi, R(3) x^*_j \right) = \left( 1 - \phi_1 \frac{EU'(1)}{EU'} - \phi_2 \frac{EU'(2)}{EU'} \right) \cdot V^e_j
\end{align*}
\]

(A4)
Collecting terms and applying additional definitions that: \( ER_{x_j} = E(P \cdot \partial Q/\partial x) = EVMP \).

\( EU' = EMU \), and that \( \lambda = -EV''/EU' \) equation (A4) can be re-written as:

\[
\left( \sum_{i=1}^{n} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \cdot \frac{EVMP(i)}{EVMP_j} \right) \cdot EVMP_j = \]

\[
V_j^{\text{eligible}} \cdot \left[ 1 - \sum_{i=1}^{2} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \right] + \lambda \cdot (1 - \Delta) \cdot \left[ \text{cov}(R, VMP_j) + \text{cov}(G, VMP_j) \right]
\]

Finally recognizing that profits will vary with respect to revenues and government payments, \( G \), then \( \text{cov}(\pi, VMP_j) = \text{cov}(R, VMP_j) + \text{cov}(G, VMP_j) \) and equation (A5) can be written as equation (2) in the text:

\[
\left( \sum_{i=1}^{n} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \cdot \frac{EVMP(i)}{EVMP_j} \right) \cdot EVMP = \]

\[
V_j^{\text{eligible}} \cdot \left[ 1 - \sum_{i=1}^{2} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \right] + \lambda \cdot (1 - \Delta) \cdot \left[ \text{cov}(R, VMP_j) + \text{cov}(G, VMP_j) \right]
\]

Next, the first order conditions with respect to non-eligible inputs are:

\[
\frac{EU(\pi)}{\partial x_j} = \left( 1 - \phi_1 \right) \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(1) \cdot R(1)_{x_j} \cdot f(\omega) d\omega + \left( 1 - \phi_2 \right) \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(2) \cdot R(2)_{x_j} \cdot f(\omega) d\omega
\]

\[
+ \int_{\omega_{\text{min}}}^{\omega_{\text{max}}} U'(3) \cdot R(3)_{x_j} \cdot f(\omega) d\omega = V_j^{ne}.
\]

And after similar manipulation this first order condition can be written as:

\[
\left( \sum_{i=1}^{n} (1 - \phi(i)) \cdot \frac{EMU(i)}{EMU} \cdot \frac{EVMP(i)}{EVMP_j} \right) \cdot EVMP = \]

\[
V_j^{\text{non-eligible}} + \lambda \cdot (1 - \Delta) \cdot \left[ \text{cov}(R, VMP_j) + \text{cov}(G, VMP_j) \right]
\]
Data Appendix

Table A1: Factor shares, and supply elasticities

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<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>C grains</th>
<th>Oilseeds</th>
<th>Elasticity</th>
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<td>Farm-own capital</td>
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<td>0.21</td>
<td>0.23</td>
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<td>land</td>
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<td>0.09</td>
<td>0.15</td>
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<tr>
<td>other purchased</td>
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<td>0.29</td>
<td>0.21</td>
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<tr>
<td>chemicals</td>
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<td>0.08</td>
<td>0.15</td>
<td>2.5</td>
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<tr>
<td>Fertilizer</td>
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<td>0.22</td>
<td>0.16</td>
<td>2.5</td>
</tr>
<tr>
<td>Machinery &amp; equip</td>
<td>0.21</td>
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Table A2: Factor substitution elasticities

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<th>Land</th>
<th>Purchased</th>
<th>Chemical</th>
<th>Energy</th>
<th>Fertilizer</th>
<th>M&amp;E</th>
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</thead>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other purchased</td>
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<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chemicals</td>
<td>0.9</td>
<td>0.5</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>0.9</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td>0.9</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinery &amp; equip</td>
<td>0.9</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
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</tbody>
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Table A3: Demand Elasticities

<table>
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<th>Wheat</th>
<th>C grains</th>
<th>Oilseeds</th>
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<td>0.3</td>
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<td>C grains</td>
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<td>oilseeds</td>
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<td><strong>-0.08</strong></td>
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