THE AGGREGATE IMPACTS OF INDIVIDUAL-BASED
INCOME SUPPORT PROGRAMS FOR FARMERS

A Thesis Submitted to the College of
Graduate Studies and Research
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
in the Department of Agricultural Economics
University of Saskatchewan

By

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Summer, 1995

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SUMMARY OF DISSERTATION

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of the requirements for the

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The Aggregate Impacts of Individual-Based Income Support Programs for Farmers

Farm income support policies along the lines of a whole-farm Net Income Stabilization Account (NISA) are fundamentally different the more traditional commodity-specific price support schemes in that the unit of measurement is the individual farm rather than the individual unit of production. Methodologically, the aggregate effects of price supports can be analyzed solely by reference to aggregate data, using aggregate supply and demand curves. This is not possible with whole-farm income support programs, where policy rules on contributions and withdrawals operate at the individual farm level. An earlier study by STHMN (1995) attempted to estimate the aggregate effects of a whole-farm income support program by first simulating the effects on a number of representative farms (representing different farm sizes, types and regions) and then aggregating up. A fundamental deficiency in that earlier work was that the authors failed to allow for supply response to the program. The purpose of the present study is to correct this deficiency by incorporating supply response into the methodology. A major challenge in this is to ensure consistency between the derived individual supply functions for the representative farms and the (directly estimated) aggregate supply function. In this study, supply (as measured by crop area) is assumed to be a function of the first two moments of net income per acre. A NISA-type income support program is expected to have a positive influence on the first moment and a negative influence on the second moment.

The study found that ignoring supply response results in: (i) a downward bias in the estimated GM per acre and aggregate gross margin; (ii) an upward bias in the estimated enhancement to net income; (iii) a downward bias in the government costs; and (iv) a downward bias in crop area under a NISA-type program.
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ABSTRACT


This thesis is a methodological analysis of whole-farm support policies along the lines of the Net Income Stabilization Account (NISA) for grains and oilseeds in Saskatchewan. Such support policies differ from commodity-specific schemes (i.e., price support) in that the unit of measurement is the individual farm rather than a unit quantity of the commodity. Methodologically, price supports can be analyzed solely by reference to aggregate data, generally using aggregate supply and demand curves. This is not possible with whole-farm income support programs, where policy rules on contributions and withdrawals operate at the individual farm level. To analyze the aggregate effects of whole-farm income support policies it is necessary to work at both the aggregate and individual farm level ensuring consistency between the two. The work in this thesis built upon and attempted to correct a fundamental deficiency in earlier work by Spriggs, Taylor, Hosseini, McLennan, and Niekamp (STHMN, 1995) which attempted to estimate the aggregate (provincial-level) effects of a NISA-type whole farm income support program for grains and oilseeds in Saskatchewan. The fundamental deficiency in that earlier work was that the authors failed to allow for supply response to the program. The purpose of this study was to develop an appropriate methodology to analyze the aggregate effects of a NISA-type whole farm program for farmers. An appropriate methodology was developed to conduct this study.

Under the SR scenario aggregate crop area was estimated to increase by three percent due to the support program. Thus, crop area was specified as a function of the first two moments of farm-based net income. Furthermore, the study found that gross margin (GM) per acre and aggregate gross margin under the supply response (SR)
scenario were higher than that under the no supply response (NSR) scenario. This suggests that, ignoring supply response, results in an downward bias in the estimated GM per acre and aggregate gross margin. The enhancement to gross margin at both the individual and aggregate levels under the SR scenario was lower than that under the NSR scenario. This implies that ignoring supply response, results in an upward bias in the estimated enhancement to gross margin. The aggregate effect of the NISA-type program on government costs under the NSR scenario was a slight downward bias relative to the SR scenario.
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This thesis is dedicated to the author's family, Mahin, Zeinab, Fatemah, and Hossein.
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CHAPTER 1

INTRODUCTION

1.1 Problem Setting

Agricultural production is generally a risky process. It is affected not only by natural forces such as weather, frost, and hail but also by political and economic conditions such as domestic agricultural policy, price fluctuations and international markets. All these factors contribute to variation and instability in farm income. In particular, the causes of instability in farmers' income are price fluctuations or price risk and/or production instability or yield risk.

The instability of farm income in the Canadian agricultural sector has promoted several distinct types of government intervention in recent years. The main objective of all of these income safety net programs is to ensure greater long-term income stability for producers. Stability reduces the business risks and consequently the financial risk associated with fluctuations in market prices or production costs. This security permits the farmer to undertake long-term investment with the confidence that net cash flow will be available in the future to cover any financing costs. More generally, providing income stability has two major purposes as an agricultural policy instrument. First, it can provide existing farmers with the means to remain in production during crisis periods. Second, it can be used to encourage new entrants to expand supply.

There are two prevailing, though not exclusive, views on why agricultural policy makers would want to do this. The traditional view is that government becomes involved to serve the public interest and increase public welfare. The alternative view is that government intervention is in response to political pressure by individuals or groups. As
a result, individuals or groups with common interests (i.e., interest groups) lobby politicians for regulations and programs that are favorable to them.

Government intervention in Canadian agricultural markets to stabilize commodity prices and producer incomes has had a long tradition. Canadian approaches to farm safety nets can be classified as the commodity-specific approach and the whole-farm approach. Intervention has been at both the federal and provincial level and has been for the most part in the form of commodity-based legislation.

Among many studies, Spriggs and Van Kooten (1988) discussed the problems that arise when commodity-based subsidy programs are used and they pointed out that it is time to consider moving away from commodity-based stabilization programs. The Canadian income safety net system is undergoing major change. The program for the livestock sector, the National Tripartite Stabilization Program (NTSP), has been discontinued (Spriggs and Taylor, 1994). Fiscal budgetary constraints and trade implications of agricultural support are factors which have led to serious reconsideration of the way in which governments intervene in agriculture.

The Federal Minister of Agriculture has supported a whole-farm approach to income stabilization which allows for all commodities to be under a single program. It is perceived that a whole-farm safety net would be more production-neutral and, hence, would be less subject to countervail. The whole-farm approach would facilitate making the program generally available, which would also be desirable from the point of view of mitigating countervailing action. The Net Income Stabilization Account (NISA) can be regarded as a whole-farm scheme to stabilize income which would include all commodities under a single program. Two factors are fundamentally different in a whole-farm approach like NISA compared to other, more familiar, safety nets (Spriggs and Taylor, 1994). First, these schemes are based on the income of individual farmers. Safety nets that we have seen in the past have been triggered by the income conditions of a specific commodity or sector. Second, the whole-farm approach would base program benefits on some measure
of total individual farm income, rather than on income from a particular commodity or commodities. A previous multi-commodities income safety net program, the Western Grains Stabilization Act (WGSA), was based on aggregate rather than individual income. The NISA scheme is also multi-commodity in nature but it is different in that the policy rule for income stabilization is on the individual farm rather than the aggregate situation.

NISA differs from other support programs such as price supports in that the unit of measurement is the individual farm income rather than units of the commodity income. From a methodological perspective, price supports can be analyzed solely by reference to aggregate data, generally using aggregate supply and demand curves. This is not possible with whole-farm income support programs, where policy rules on contributions and withdrawals operate at the individual farm level. Methodologically, work needs to be completed to ensure consistency between the aggregate and individual farm levels.

Previous attempts at assessing aggregate policy effects based on analysis of individual farms include a large body of work carried out in the 1950s and 1960s, which is summarized by Sharples (1969). These modeling attempts have tended to focus on either the micro level (the individual) or on the macro level (the aggregate). Separating these approaches has not been entirely satisfactory for policy analyses, in part because of: (i) invalid estimates from micro models attributable to assumptions that some aggregate variables, such as price, remain unchanged when in fact they are affected by the resulting behavior of the sector as a whole; (ii) macro models' lack of structural specification or flexibility to estimate detailed (distributional) impacts; and (iii) macro model results often being invalid because of possible aggregation bias. Specifically, aggregate functions derived from individual firm-level relationships did not approximate well the aggregate functions based on aggregate data. Ultimately, researchers moved away from this kind of approach because of problems of aggregation. Consequently, the motivation for doing this study is the perceived need for a quantitative and qualitative framework to work at both levels and to ensure consistency between them.
The purpose of this dissertation is to discuss the issues involved in aggregation over individuals in supply response analysis, and to present and implement an aggregation-consistent individual level methodology of supply response which involves both specifications for micro and macro supply behavior, connected by an aggregation scheme. Although the illustration of this methodology is confined to analyzing supply response, the concepts are applicable to any study of aggregation over individuals, where the policy rules operate at the individual level. More specifically, the illustration of this methodology will build on and attempt to correct a fundamental deficiency in earlier work by Spriggs, Taylor, Hosseini, McLennan, and Niekamp (STHMN, 1995) which attempted to estimate the aggregate (provincial-level) effects of a NISA-type whole farm income support program for Saskatchewan. The fundamental deficiency in that earlier work was that the authors did not allow for supply response to the program. The objective is to analyze the aggregate effects of such a policy where policy rules operate at the individual level.

1.2 Objectives of the Thesis

The general objective of this thesis is to develop an appropriate methodological approach for analyzing the effects of farm income stabilization programs at the aggregate level when the policy impacts directly at the individual level.

There are three specific methodological objectives to be addressed: (1) estimation of individual representative supply functions that are consistent with an estimated aggregate supply function; (2) simulation of the policy effects at the individual level; and (3) aggregation of the policy effects measured at the individual level.

To illustrate these methodological developments empirically, they will be applied to the case of the basic NISA program in grains and oilseeds farms in Saskatchewan. The program will be analyzed with respect to how it will affect the Saskatchewan agricultural sector in terms of aggregate disposable income, aggregate costs, and aggregate crop area.
1.3 Organization of the Thesis

Chapter 2 consists of a review of previous approaches to modeling how government policies affect the agricultural sector. In this chapter a substantial literature on modeling supply response with respect to policy variables with risk and without risk at the individual level as well as at the aggregate level will be reviewed. Also, previous approaches to aggregation and Canadian approaches to farm income support programs will be discussed. In Chapter 3 the methodology of analysis will be outlined and developed. Chapter 4 illustrates how this methodology can be applied, in this case in an empirical analysis of the basic NISA program. Chapter 5 presents the implications of the empirical analysis. Chapter 6 consists of the summary and conclusions, and suggestions for further study.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The major task of this thesis is to provide an appropriate quantitative and qualitative methodology which combines the aggregation over individuals with the supply response for analyzing aggregate impact of the whole-farm income support programs (e.g., basic NISA), where policy rules on contributions and withdrawals operate at the individual farm level. The main components of such a model can be related to: (i) the basic firm theory underlying supply response; (ii) the methods of supply response; (iii) supply response under risk; (iv) aggregation and disaggregation issues; and (v) the commodity-specific and whole-farm approaches to farm safety nets.

This chapter reviews previous models that sought to describe how government policies affect the agricultural sector. These modeling efforts tended to focus on either the micro-system (the firm) or on the macro-system (the aggregate). In section 2.2 is a review of the basic firm theory underlying supply response and the methods of analyzing the supply response. In section 2.3, supply response under risk is addressed. In section 2.4 aggregation and disaggregation issues are discussed. In section 2.5 the theoretical approaches to estimating the effects of government programs on agricultural supply is reviewed. The final section of the chapter addresses a review on the Canadian agricultural stabilization programs.
2.2 The Basic Firm Model and the Models for Analyzing Supply Response

Understanding the behavior of individual agricultural decision makers in the process of aggregation is one of the most basic endeavors of the agricultural economics profession. Understanding agricultural prices and markets, agricultural finance and credit institutions, the effects of alternative agricultural and environmental policies, and the effects and benefits of new policy all depend fundamentally on understanding the behavior of farmers in the production process. Therefore, in this section the basic firm model as well as the methods of analyzing supply response will be reviewed.

2.2.1 The Basic Firm Model

Just (1993) summarized the agricultural production problems in the context of a micro-model which are characterized by: (i) production relationships, (ii) constraints, (iii) accounting relationships, (iv) the behavioral criteria of the producer, and (v) characteristics criteria of the producer. He indicated that the economic production function at the individual firm level is generally expressed as an explicit functional relationship between all output and all variable and fixed inputs:

\[ q = f(X,Y,Z) \]  \hspace{1cm} (2.1)

where \( q \) is an \( m \)-vector of outputs, \( X \) is an \( m \times n \) matrix of allocations of \( n \) variable inputs to \( m \) production activities, \( Y \) is an \( m \times k \) matrix of allocation of \( k \) fixed inputs to \( m \) production activities, and \( Z \) is an \( h \)-vector of non-allocable fixed factors.

The constraints can be represented by

\[ Ye = y \]  \hspace{1cm} (2.2)
where \( y \) is a \( k \)-vector of farm-level allocable resources and fixed inputs and \( e \) is an \( m \)-vector of ones. Similarly, the accounting relationships for variable inputs are represented by

\[
Xe = x \tag{2.3}
\]

where \( x \) is a \( n \)-vector of farm-level purchased-input quantities and \( e \) is a \( m \)-vector of ones.

The behavioral criteria are expressed by

\[
U(P.q.W.x.X.y.Y.Z)
\]

where \( U \) is utility function, \( P \) is a vector of output prices associated with \( q \), and \( W \) is a vector of variable input prices associated with \( y \).

Given the behavioral criteria for the firm of the form above and information on the nature of the relationships involved, it is possible to derive functions expressing outputs, costs and derived demands for inputs in terms of given prices of the outputs and inputs. In principle, the behavioral criteria imply input decision and output allocation at the micro-level.

Just's equations were:

\[
Y^* = Y^*(P.W.y.Z) \tag{2.4}
\]

\[
X^* = x^*(p.w.y.z) \tag{2.5}
\]

where \( Y^* \) is an \((m-1)\times k\) matrix consisting of the first \( m-1 \) columns of \( y \). Substituting (2.2), (2.4), and (2.5) into (2.1) obtains the supply equation.

\[
q = q(P.W.y.Z) \tag{2.6}
\]
and substituting (2.5) into (2.3) obtains the variable input demand equation.

\[ x = x(p, w, y, z) \]  

(2.7)

The model in equations (2.1) through (2.5) is the basic microeconomic model underlying agricultural production analysis, supply and demand estimation, agricultural policy and trade analysis. In the present study, the supply function will be based on \textit{ex ante} rational expectations. As such, it will be a function of two arguments: the expected per-acre revenue and the variance of per-acre revenue.

\textbf{2.2.2 Models for Analyzing Supply Response}

One of the major tasks in this study is to recover the individual supply response function from an estimated aggregate supply function in an implementation of aggregation methodology. Therefore, this section will review models for analyzing supply response. The emphasis in supply response analysis is on the changes in production or supply that will take place through time as economic conditions change. Acreage supply response models are used to both quantify and predict producer planting decisions. These models describe how planting decisions change in response to exogenous shocks such as changes in the prices, and their predicted future response. Many models have been developed to describe production in Western Canada (Miranda, Novak and Lerohl (MLN), 1994). These models were used as forecasting tools to predict future supply of a given commodity, or as policy analysis tools, to test the impact and effectiveness of current or future government programs. The present study will assume an acreage supply function along the lines MLN (1994).

Recent surveys of supply response models have identified four distinct types of commonly used models (Just, 1993, Colman, 1983). Askari and Cummings (1977), Colman (1983), Henneberry and Tweeten (1991) and Just (1993) have identified four
distinct types of commonly used models for analyzing supply response in their surveys of the supply response function. Based on this literature, these models can be classified into four broad empirical approaches: (i) programming models, (ii) myopic econometric analysis, (iii) structured direct econometric models, and (iv) structured indirect econometric models-duality.

(i) Programming Models

The programming approach has been used to analyze agricultural production, policy and supply by creating a complete system which represents the relationships in equations (1)-(5). Programming models use a mathematical programming approach to simulate the profit maximization of individual producers. Using actual market conditions for each period included, linear programs determine ideal outcomes for several types of farms. The result is aggregated over homogeneous representative farms to derive aggregate supply response. This method is also known as the representative farm approach (RFA).

The representative farm approach was by far the most popular research approach used for both firm and aggregate supply response analysis during the 1960s (Sharples, 1969). Aggregate supply response was based on the aggregation of representative farm results. The RFA later became the foundation of the regional adjustment study research.

Sharples (1969) outlined the broad objectives of using this approach as: (1) to determine individual farm adjustments that could be made to maximize profits; (2) to assess the aggregate effect if these individual adjustments were made; and (3) to determine further adjustments needed at the farm level to reflect changing supply-demand conditions. Barker and Stanton (1965) classified these objectives as conditionally normative.
Sharples outlined the RFA model's components as: (1) stratify all farms within a region into homogenous groups, (2) define a representative farm for each stratum, (3) derive supply functions for each farm, (4) aggregate the supply functions, and (5) remove the model's simplifying assumptions. Sharples (1969) called this model a "representative farm aggregation" model.

One perceived advantage of the RFA was that it seemed to provide the missing research link between the firm and the industry (the micro-level and the aggregate level). Another was that the normative characteristics of the RFA model would allow its use for studying conditions that had not occurred in the past.

Problems with the RFA model can be grouped into five categories (Sharples, 1969, and Kirman, 1992): (1) interdependence or externalities, (2) change in farm size, (3) unrealistic firm-level assumptions, (4) the selection of representative farms, and (5) mechanical problems.

This model is used to describe behavior by representative farms subject to prices and resource availability. Specifically, this approach has been applied to the derivation of a supply response function in many studies including Heady and Candler (1958), Cowling and Baker (1963), Miller and Heady (1973), and Thompson and Buckwell (1979). The representative farm approach is the basic unit in building the aggregate model for the present study.

(ii) Myopic Econometric Analysis

Most econometric production studies attempted to estimate single-equation productions that are often characterized by Cobb-Douglas technology. However, most market analyses that attempt to estimate single-equation supply functions are characterized by the Nerlovian supply model. Colman (1983) called these models directly
estimated partial commodity supply models and suggested that the majority of agricultural supply response studies fall into this class.

(iii) Directed Econometric Models

A directly estimated supply system is a set of supply response equations for a number of related crops, estimated either jointly or as separate equations. This type of model is used to estimate all of the observable relationships simultaneously in a consistent framework (Just, 1993, and Colman, 1983). This can be accomplished by adopting a specification for the production function (2.1) and the behavioral criteria and then deriving (2.4) and (2.5). This approach has been developed for the case of multiple outputs and constraints across production activities (Just, Zilberman and Hochman, 1983).

(iv) Indirect Econometric Models (Duality Theory)

One approach that has gained increasing interest over the past fifteen years is based on duality theory. In comparison to (i) and (iii), the dual approach is clearly a major advance in consistent estimation of agricultural supply. The dual approach is clearly an advance in consistent interpretation of agricultural data and more efficient estimation of agricultural supply because it facilitates consistent specification for supplies and demands. Following Shephard (1953), McFadden (1978) recognized econometric simplifications made possible by a duality between production and profit or cost functions. More recently, Alston, Norton, and Pardey (1995) listed the potential advantages of the dual approach. These were: (i) the use of factor prices, rather than their quantities, as explanatory variables which may avoid the problems of simultaneity that arise when input choices are jointly endogenous with output; (ii) the dual representations, combined with their derivative properties, permit the estimation of a system of equations
comprising the cost function and the system of output-constrained factor-demand functions.

Alston et al. (1995) considered three corresponding categories of approaches to estimate supply response: (i) primal (two-stage) models; (ii) dual (two-stage) models; and (iii) directed single-equation supply models. They illustrated these approaches in a figure (reproduced as 2.1) which was adapted from Colman (1983). These approaches were shown within the neoclassical theory of the firm. The first route estimates a production function and then imposes upon that function some behavioral assumptions in order to deduce the implied supply response. The second route estimates a cost function and its corresponding input demand function and then uses derivative properties to deduce supply response. The third route estimates the supply response directly in such a way that behavioral assumptions are minimized, but as a result, there is no guarantee that the estimates are consistent with any particular set of behavioral assumptions.

A consistent system of input demand equations such as (2. 7) can be derived from an underlying cost function specification (e.g., Binswanger, 1974). A consistent system of input demands and supplies such as (2. 6) and (2. 7) can be derived from an underlying profit function specification.

A number of studies of agricultural supply have employed what in Figure 2.1 is labeled following Route 1, where single-commodity or aggregate production functions are estimated from cross-section farm data or from time series, and these are used to generate output supply response functions. Such studies include the supply response studies of Schuh (1975), and the aggregate supply response studies of Griliches (1963).

The development of more flexible functional forms, such as the constant-elasticity-of-substitution (C.E.S) and transcendental logarithmic has broadened the scope for pursuing route 1. Derivation of agricultural supply response estimates via route 2, a
Source: Colman (1983).

where: \( \Rightarrow \) = a dual relationship.

\( q \) = vector of outputs and \( x \) is a vector of inputs.

\( p \) = vector of output prices

\( r \) = vector of input prices.

\( z \) = vector of fixed input quantities.

\( \pi \) = profit, and

\( c \) = cost.

\( * \) = profit maximizing or cost minimizing level.

**Figure 2.1.** Relationships between supply functions and other functions in the theory of the competitive firm
profit function. has been extensively performed by Lau and Yotopoulos (1972) and Yotopoulos, Lau, and Lin (1976).

Application of the duality principle permits the pursuit of Route 3 in Figure 2.1 to obtain an estimate of supply response behavior.

2.3 Supply Response under Risk (Risk Response Model)

In the present study, one of the major components of a supply response function in the process of aggregation is the risk variable. In the following section the major risk response models will reviewed.

Over the years, agricultural economists have analyzed the motivation and performance of various farm income-support programs (e.g., Cochrane and Ryan, 1971). The usual argument is that unique features of farming and agricultural commodity markets generate a "farm problem". The sources of the "farm problem" include market failure, low farm income and income instability. If this is true, then an economic evaluation of farm programs using riskless models is inappropriate. This is an important issue in identifying and measuring the benefits from stabilization programs.

Risk may be characterized by variance and higher moments of the probability distribution of relevant variables. If a farmer's utility function is quadratic or profits are normally distributed, then mean and variance are the only factors necessary to describe the characteristics of the probability distribution of profits. Hence one representation of risk may be the variance of profits.

Risk is an important factor that influences production decisions, and causes both inefficient use of factors of production and instability of farm income. A government farm program like the Net Income Stabilization Account (NISA) is one potential means of
reducing the instability of farm income and thereby increasing the efficiency of factor allocation and use.

This section reviews the major models of supply response under risk. Two important possibilities exist with respect to risk for the quantitative determination of farmers' response to stabilization or destabilization of input price, output prices and yields. There are two basic approaches for estimating supply response with risk (Nerlove and Bachman, 1960) : normative risk response and positive risk response. These are discussed in the following.

2.3.1 Normative Risk Response

The normative risk response (NRR) approach is often used to study supply response with risk at the farm level. The NRR is specified by mathematical programming studies of the optimal resource use by a given farm unit (Hallam et. al., 1982). The objective of a farm is to maximize profits or expected profits. In the NRR, a mathematical (programming or control theoretic) model that includes price and yield risk can be developed for various farm classifications. By aggregating results over classifications, the net response to specific changes in risk structures can be examined (Just, 1975).

The NRR has not been widely used in aggregate supply analysis other than under the assumption of profit maximization. A few studies, such as the ones discussed by Hazell and Scandizzo (1974) and Hazell (1982), attempt to include risk response in an aggregate normative model. However, the methodology for determining individual preferences has been progressing. Among others, Webster and Kennedy (1975), have developed methods for the estimation of individual utility functions of agricultural producers. All NRR models have restricted decision makers' objective criteria for maximization of a mean-variance utility function of profit.
2.3.2 Positive Risk Response

The positive risk response (PRR) approach is often used to study supply response with risk at the aggregate level. This approach is specified by econometric estimation of a supply response equation based on historical data (Hallam, et. al., 1982). The PRR is more direct because information about objective criteria need not be specific. Simple econometric models of risk response have been used for studying acreage response to both output price risk and yield risk (Behrman, 1968; and Just, 1975). In the present study an estimated aggregate supply function will be used to derive the individual supply function in a consistent way. In this aggregate supply function, crop area will be a function of first and second moments of net returns/acre.

Various researchers have incorporated risk in supply response functions in the following ways: (i) the general adaptive expectations model, (ii) the regional linear programming risk response model, (iii) the direct supply risk response model, (iv) the maximization of expected utility model, and (v) the aggregate risk response model.

(i) General Adaptive Expectations Model

The major approach developed thus far in estimating aggregate risk response involves modifying the general class of adaptive expectations models. Just (1975) developed an adaptive expectations model in which supply is related to lagged expectations in both the mean and variance of past revenues. Application of this model shows that supply can be quite responsive to change in the variance of revenues.

Just's model for an individual farm was:

\[ y_t = f(x_t^*, z_t^*) \]

\[ x_t^* = \sum_{k=1}^{\infty} a_k x_{t-k} - k \]
\[ z_t^* = \sum_{k=1}^{\infty} \beta_k x_{t-k} \]

where \( x_t^* \) and \( z_t^* \) represent subjective expectations for \( x_t \) and \( z_t \), respectively, for time \( t \).

With this model, the squares and cross products of the errors of predictions are given in the resulting adaptive risk model:

\[ y_t = f^* \left( x_t^*, z_t^*, u_t, v_t, w_t \right) \]

where:

\[ u_t = \sum_{k=1}^{\infty} g_k \left( x_{t-k} - x_{t-k}^* \right)^2 \]

\[ v_t = \sum_{k=1}^{\infty} d_k \left( z_{t-k} - z_{t-k}^* \right)^2 \]

\[ w_t = \sum_{k=1}^{\infty} x_r \left( x_{t-k} - x_{t-k}^* \right) \left( z_{t-k} - z_{t-k}^* \right) \]

His model included the subjective variances as well as subjective covariance. He simplified the response function for an individual farm as follows:

\[ y_i = a_0 + a_1 x_i^* + a_2 \left( x_i - x_i^* \right)^2 \quad i = 1, \ldots, n. \]

where \( x_i^* \) is the \( i^{th} \) decision makers' weighted average price over some lag period and \( x_i \) is the most recent price observation. Just indicated that the corresponding aggregate model of the individual model is:

\[ Y = a_0^* + a_1^* X^* + a_2^* \left( X - X^* \right)^2 \]
where:

\[ Y = y_1 + y_2 + \ldots + y_n \]
\[ X = \frac{(x_1 + x_2 + \ldots + x_n)}{n} \]
\[ X^* = \frac{(x_1^* + x_2^* + \ldots + x_n^*)}{n} \]

Since \( a_0^* + a_1^* x^* = (a_0 + a_1 x_1^*) + (a_0 + a_1 x_2^*) \) for all \( x_1^* \) and \( x_2^* \), if \( a_0^* = 2a_0 \) and \( a_1^* = 2a_1 \), there is no aggregation bias in this part. However, as will be shown later in Chapter 3, aggregation bias exists in the aggregate risk term. Behrman (1968) and Just (1975) applied these types of models in studies of crop-supply response. The majority of econometric models used the adaptive expectation models, in which area planted is a function of expected prices. However, the present study will use an *ex ante* rational expectations acreage supply model in which crop area will be a function of expected net return per acre and net return variance per acre. Revenues are generated using randomly chosen prices and yields from specified multivariate probability distributions.

(ii) Regional Linear Programming Risk Response Model

The regional linear programming model has been used to estimate supply response. The model incorporates the most important actual constraints and takes into account farmers' attitudes as risk-averse individuals.

Pomareda and Samayoa (1979) implemented and applied this model for area and yield response to price policy in Guatemala.

Their model was:
\[ Q_i = f\left(Y_i, A_i\right). \]

\[ Y_i = g\left(\frac{P_i}{P}, C, W, T_{is}\right). \]

\[ A_i = h\left(\frac{P_i}{P_j}, C\right). \]

where \( Q_i \) is total production, \( Y_i \) is yield per unit of area, \( A_i \) is area planted, \( p_i \) is the expected price, \( P \) is an aggregate of expected prices, \( W \) is a factor for weather and other elements that make yields stochastic, \( T_{is} \) is the technology \( s \) for crop \( i \), and \( C \) is an aggregate of input prices.

They conducted the model for risk-averse farmers, where the model was written as follows:

\[
\text{Max} \sum_i p_i Q_i - \sum_i \sum_k \sum_s C_k b_{iks} - \Phi V^{1/2}. \\
\text{subject to} \quad b_{iks} \leq B_k.
\]

where \( C_k \) is the price of the \( k \text{th resource} \), \( b_{iks} \) is the amount used of the \( k \text{th resource by the} \ i \text{th crop} \), \( B_k \) is a vector of resource constraints, \( V \) is a variance-covariance matrix of gross returns (which accounts for risk response), and \( \Phi \) is a subjective constant risk-aversion parameter. The model was solved at an alternative level of \( \Phi \) for two groups of producers to measure risk-aversion among producers.

(iii) Direct Acreage Supply Risk Response Model

This model was used to determine the importance of risk in the market equilibrium framework by using a structural econometric model at the industry level.

Broersen, Chavas, and Grant (1987) used this model to investigate the impacts of risk in acreage and yield equations for five rice-producing states. The acreage equations were:

$$A_{it} = f_i\left(P^*_t - 1, A_{it-1}, D_{83t}, RiskS_{it}\right)$$

where $A_{it}$ is acreage planted in state $i$ in year $t$, $P^*_{t-1}$ is effective farm price as defined by Houck and Ryan (1972) and deflated by the variable cost of production, $D_{83}$ is a dummy variable representing the impact of the 1983 payment-in-kind program (PIK), and $RiskS_{it}$ is the risk variable.

They defined the risk measure, which reflects variability in income per acre in state $i$ at time $t$ ($Inc_{it}$), as follows:

$$Inc_{it} = P_{it}Y_{it} - COP_{it} + GP_{it}.$$  

where $P_{it}$ is the farm price of rough rice in state $i$ in time $t$, $Y_{it}$ is yield per acre, $COP_{it}$ is the variable costs per acre of producing rice, and $GP_{it}$ is direct government payment per acre. The risk variable was specified as the square root of a weighted moving average of the square relative deviation of actual income from expected income. Thus, the measure of risk in supply is:

$$RiskS_{it} = \left\{ \frac{3}{\sum_{j=1}^{3} a_j} \left[ \frac{(Inc_{it} - j - Inc_{it} - j - 1)}{Inc_{it} - j - 1} \right]^2 \right\}^{1/2}$$
They identified the impact of risk reduction in a market context and provided useful information on potential benefits for market stabilization programs. They concluded that risk had a negative impact on acreage planted and it was significant at the 10% level for four of the five states.

(iv) The Maximization of Expected Utility Model

Freund (1956) was the first to develop a farm production model incorporating risk aversion. He assumed an exponential utility function for income of the form

\[ U = 1 - e^{-\beta y}, \]

where \( U \) denotes utility, \( y \) denotes income, and \( \beta \) is a risk-aversion parameter. Assuming that income is normally distributed, expected utility can be calculated as \( E(u) = E(y) - 1/2 \beta V(y) \), which is linear in the mean and variance of income.

Freund maximized this function subject to a set of linear resource constraints using quadratic programming. Also, studies by Dillon and Scandizzo (1978), and Moscardi and de Janvry (1977) suggest that individual utility functions may not be stable over time (i.e., risk aversion may change) because they vary with the socioeconomic status of the household.

Hallam, Just, and Pope (1982) developed a dual expected utility function to assess supply response with risk. The farmers' objective under risk was to maximize the expected utility of profits, which was:

\[ \max E\{U(\pi)\} = E\left\{U \sum_{i=1}^{n} r_i(x_i, p)A_i - w^*A' - F\right\} \]

where \( \pi \) is profits, \( r_i \) is the gross return per acre planted to the \( i^{th} \) crop, \( x_i \) is a vector of inputs per acre used in the production of the \( i^{th} \) crop, \( A' \) is a vector of the acreage
planted to \( n \) crops, \( w \) is a vector of input prices, \( p \) denotes policy transfers to the crops, and \( F \) is fixed costs of production. Their solution to the above problem was:

\[
A^*_i = A_i(r, w, p) \\
x^*_i = x_i(r, w, p)
\]

where \( r = [r_1, ..., r_n] \) and \( w = [w_1, ..., w_n] \).

The revenue of producing crop \( i \) is equal to the product of output price and output quantity. Let \( r_i \) be a stochastic return \( r_i = r^*_i + \sigma_i \) where \( r^*_i \) denotes a farmer's expected return of the \( i^{th} \) crop per acre, and \( \sigma_i \) is risk associated with growing the \( i^{th} \) crop. Since \( r = r^*_i + \sigma_i \), the acreage response and input-demand equations are:

\[
A^*_i = A_i(r^*, \sigma, w, p) \\
x^*_i = x_i(r^*, \sigma, w, p)
\]

(v) Aggregate Risk Response Model

Recent years have seen rapid advances in the development of techniques for incorporating risk-averse behavior in agricultural decision models at the farm and sector levels. At the aggregate level, mathematical programming models provide the most explicit way of modeling aggregate risk behavior.

A major difficulty in incorporating producers' risk behavior in aggregate supply functions is the need to aggregate individual utility functions. Since the expected utility is based on ordinal preference indices and these indices are only defined up to linear transformations, they cannot strictly be added over individuals. One important consideration is the need to aggregate risk preferences in ways that ensure that the marginal cost of risk in aggregate supply is equal to the sum of the marginal risk costs for individual producers (Hazel, 1982).
Dillon and Scandizzo (1978) and Hazel (1982) showed that the parameters in the $E - \beta V$ and $E - \phi \sigma$ decision criteria are invariant to linear transformation formations in the underlying utility-of-income functions. Therefore, these parameters can be averaged over individuals (Dillon and Scandizzo, 1978).

Suppose each farmer's attitude to risk can be described as $(E - \phi \sigma)$, the relevant measure of risk at the aggregate level is then $\Phi \Gamma = \sum_i \phi_i \sigma_i$, where $i$ denotes the $i$th farm and $\Phi$ and $\Gamma$ are, respectively, appropriate aggregates of $\phi_i$ and $\sigma$. If $\Gamma$ is chosen as the aggregate risk variable $\sum \sigma_i / n$, then $\Phi$ must be defined as a weighted average of the individual farm risk parameters.

Hazell and Scandizzo (1974) developed a linear programming method for solving agricultural sector models to obtain perfectly competitive levels of outputs and prices in all product markets when producers decide according to an $(E - \beta V)$ or $(E - \phi \sigma)$ decision criteria. They developed a sector model to obtain competitive market equilibrium corresponding to farmers holding rational revenue expectations and to farmers forming independent forecasts about their prices and yields.

Developments in the economics of risk have provided some analytical tools in the analysis of stabilization benefits. Empirical works have also addressed the influence of risk on agricultural production and distribution. The results of these empirical works indicate that increases in price and yield instability or income instability tend to decrease aggregate supply.

2.4 Aggregation and Disaggregation Issues

The main block of this thesis will be based upon the implementation of an appropriate methodology for aggregation over individual representative farms within the specification of a supply response model. This section will review the previous studies
on aggregation over individual supply functions. Previous attempts at assessing aggregate policy effects based on an analysis of individual farms include a large body of work carried out in the 1950s and 1960s, which is summarized by Sharples (1969). Aggregation functions derived from individual firm-level relationships did not approximate adequately the aggregate functions based on aggregate data. Ultimately, researchers moved away from this kind of approach because of problems of aggregation. More recently, Stoker (1994) has suggested an alternative approach to the aggregation problem that starts with an estimated aggregate function, and from this derives individual-level functions that are consistent with the aggregate level function. Policy analysis is performed on these individual-level relationships and then the individual data are summed to achieve the aggregate-level effects.

This section reviews aggregation and disaggregation issues such as aggregation vs. disaggregation, aggregation over individuals, and moving from micro-level to macro-level supply responses.

2.4.1 Aggregation vs. Disaggregation

Identification of the appropriate level of aggregation is an important issue in developing supply response models for forecasting and policy analysis. Whether to perform econometric analysis on an aggregate or disaggregate level can depend on several factors. One of the most important factors is the intended purpose of the model. For example, if the researcher intends to make inferences from the model regarding individual behavior, then a micro-level specification is generally preferred because aggregation can introduce bias into coefficient estimates. On the other hand, if the intended use of the model is to predict or to describe an aggregate dependent variable, a macro-equation may be preferred if specification or measurement errors to the micro-equations are reduced through aggregating (Grunfeld and Griliches, 1960). The decision of whether to use an
aggregate or disaggregate model is dependent on both the relative magnitudes of the specification errors in the micro-level equations and the aggregate error in the macro-equation.

Previous authors have provided the necessary statistical procedures for making comparisons between aggregate and disaggregate models. Aggregation is consistent when the use of more detailed information makes no difference to the results of the problem under consideration (Green, 1964). Zellner (1962) suggested testing the equality of coefficients across micro-level equations as a test for aggregation bias. If coefficients are equal across micro-units, then aggregate analysis produces identical estimates (Theil, 1954). However Pesaran, Pierse and Kumar (1989) pointed out that, while the absence of an aggregation bias in coefficient estimates is sufficient to ensure that aggregate and disaggregate models give the same prediction of the aggregate dependent variable (i.e., are consistent), it is not a necessary condition. The macro and micro models are also consistent when the distribution of regressors across micro-units is stable over time. When this occurs, estimated macro-parameters are averages of corresponding micro-parameters weighted according to the fixed distribution. One of the more complete applications available is by Lawrence and Zeitsch (1990), who use aggregate data to estimate a profit function with 6 crop outputs and 7 livestock outputs, and with 5 variable inputs and one fixed input.

2.4.2 Aggregation over Individuals

Stoker (1993) surveyed the empirical approaches to the problem of aggregation over individuals. He spelled out three major approaches to empirical modeling of aggregated data in the context of his survey. These approaches were: (i) modeling aggregate data alone, including the representative agent approach, (ii) modeling individual
economic behavior alone, or micro simulation, and (iii) joint modeling of individual and aggregate level data.

The first approach is the econometric modeling of aggregate data series alone. when one asserts the existence of a stable model among aggregates, and then fits the model statistically. This approach is motivated as a first-cut method of studying aggregate data patterns, for the purpose of forecasting of aggregate variables for the analysis of economic policy. One version of this approach is the traditional macroeconomic equations, which are specified and estimated in an ad hoc fashion. Stoker (1993) has pointed out in his survey that these purely statistical approaches are not well grounded in any model of (individual) economic behavior. Use of economic effects estimated in this way for policy analysis with no foundation relative to the behavior of the individual economic agents amounts to extrapolation of the recent past data into the future. This kind of traditional macro economic modeling amounts to a purely statistical approach to aggregate data series. This approach also includes the parametrized econometric models of individual firm decision making under uncertainty.

The second approach to modeling aggregate data is micro simulation. This approach begins with a full model of the behavior of each different type of individual in the sector, estimated with survey or panel data on individuals. Aggregate values are then simulated by adding up across all individuals. Examples of micro simulation models include the Joint Committee on Taxation's (1992) model for simulating tax policy impacts, and variables models of appliance choice and energy demand, such as those described by Thomas Cowing and Daniel McFadden (1984). Stoker (1993) stated that this approach has the potential for the most realistic representation of aggregation over individuals.
The third approach to modeling aggregate data is to adopt a framework that permits individual data and aggregate data to be modeled under one consistent format. In particular, an aggregate model is estimated together with assumptions that permit an individual model to be formulated that is consistent with the aggregate model. Stoker pointed out that this approach models the comparability of individual behavior patterns and aggregate data patterns and removes any mystery included by the one-sided focus of studying aggregate data alone, or individual data alone as in the two pervious approaches. This compromise between the first two approaches is typically achieved by using individual level equations that restricted to accommodate aggregation, together with information on the distributional composition of the firms. Stoker (1993) listed the advantages to such micro-macro models.

These were:

(i) Any restrictions on behavior applicable at the individual level model can be applied in a consistent fashion to the aggregate model. The parameters of individual level equations appears in the aggregate level model, and restrictions on those parameters are applicable at both levels.

(ii) Simultaneous modeling of both individual and aggregate level data permits pooling of both kinds of data, which broadly allows heterogeneity to be characterized by observed individual differences in behavior.

(iii) The results of estimating in such a model are applicable to a wide range of applied questions.

The present study proposes to use this last approach to develop an aggregation-consistent individual methodology.
Stoker (1993) pointed out that the most important development of the work of the last decade was the demonstration of how individual heterogeneity can actually be incorporated in the modeling of aggregate data.

The aggregation across firms through aggregation of the cost function, linear aggregation of output and nonlinear aggregation over individual will be discussed in the following sub-sections.

(i) Aggregation of the Cost Function

Chambers (1988) attempted to address this issues by considering the aggregation of firm-level cost functions to the industry level. His theoretical model was as follows: Assumptions: (1) all firms face the same input prices, (2) each firm will operate or want to operate at a different output level, (3) each firm produces the same output $y^*$, and (4) each firm's production is characterized by constant returns to scale.

Model:

$$C(W, Y) = \text{the industry function.}$$

$$C^i(w, y) = \text{the } i\text{th firm's cost function.}$$

$$C(W, Y) = \sum_{i=1}^{m} C^i(w, y^i).$$

where $m$ is the number of firms in the industry. Based on the above assumptions, aggregation of the cost function over individual producers is:

$$C(W, Y) = \sum_{i=1}^{m} Y^* C^i(W) = Y^* \sum_{i=1}^{m} C^i(W) = Y \sum_{i=1}^{m} \frac{1}{m} C^i(W) = YC(W).$$

where $Y = mY^*$. 

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The results show that industry costs equal the sum of costs for all firms in the industry.

(ii) Linear Aggregation of Output

Chambers outlined the linear aggregation of output under the assumption that cost functions are nonlinear in output and all firms do not produce the same level of output. His linear aggregation approach was:

Model:

\[ C(W, Y) = \sum_{i=1}^{m} C^i(W, y^i) \]  \hspace{1cm} (2.8)

\[ Y = \sum_{i} y^i \]  \hspace{1cm} (2.9)

Equation (2.9) is the unweighted sum of each firm's output.

Differentiation of \( C(W, Y) \) with respect to \( y^i \) yields:

\[ \frac{\partial C(W, Y)}{\partial y^i} = \frac{\partial C(W, Y)}{\partial Y} \cdot \frac{\partial Y}{\partial y^i} = \frac{\partial C^i(W, Y)}{\partial y^i}. \]

Thus,

\[ \frac{\partial C(W, Y)}{\partial Y} = \frac{\partial C^i(W, y^i)}{\partial y^i} \hspace{1cm} \forall \hspace{0.1cm} i \]

since \( \frac{\partial Y}{\partial y^i} = 1 \). He pointed out that the aggregation consistency that requires each firm-level marginal cost equal aggregate marginal cost is as follows:

\[ \lambda(W) = \frac{\partial C(W, Y)}{\partial Y} = \text{AMC} \]  \hspace{1cm} (2.10)

where \( \lambda(W) \) represents aggregate marginal cost. Integrating (2.8) over \( Y \) gives:
\[ C(W, Y) = \lambda(W)Y + C^*(W) \]  

(2.11)

where \( C^*(w) \) is a constant of integration. Expression (2.11) says that an aggregate cost function that is consistent with \( Y = \sum_i y_i \) must be consistent with a quasi-homothetic technology. An important implication of this result is that technical differences across firms are restricted to the \( C^*(W) \) terms.

(iii) Nonlinear Aggregation over Individuals

Stoker (1993) pointed out that when individual behavior relations are nonlinear, then exact aggregation theory is not useful, and the question is how a full micro-macro model could be built that allows for aggregation over individuals. He stated that the distribution of individual attributes must be included as a part of the model that account for heterogeneous responses. He expressed the idea through an example of demand. He considered a case under which the purchase of a single unit of a particular product is under consideration. The model follows a probit model where the individual model of purchase is:

\[
y_{it} = \begin{cases} 
  f(p_t \cdot m_{it}) \\
  1 & \text{if } 1 + \beta_1 \ln p_t + \beta_2 \ln m_{it} \geq 0 \\
  0 & \text{otherwise}
\end{cases} 
\]  

(2.12)

where \( m_{it} \) is the individual's budget, \( p_t \) is the price of product, and \( 1 + \beta_1 \ln p_t + \beta_2 \ln m_{it} \) is the net benefit (utility). Because of the (0, 1) nature of \( y_{it} \) this model is nonlinear in \( \ln m_{it} \). Adding a normal error term on the right-hand side of 2.12 would give a probit model.

The aggregate \( \frac{\sum y_{it}}{N_t} \) is the proportion of all individuals that buy the product. For modeling this proportion model it is required to structure the distribution of \( m_{it} \) and derive the aggregate model as the probability that a purchase is made. Stoker for his
example assumed a log normal distribution for \( m_{it} \) with mean 0 and variance \( \nu_t^2 \). He derived the aggregate relation by considering the probability \( E_t(y) \) of purchase as follows:

\[
1 + \beta_1 \ln p_t + \beta_2 \ln M \geq 0 \quad (2.13)
\]

In particular the lognormality assumption of \( M \) implies that \( \frac{\ln M - \mu_t}{\nu_t} \) follows a standard normal distribution with mean of 0 and variance 1. Rearranging this term gives this as the probability of

\[
-\frac{\ln M - \mu_t}{\nu_t} \leq \frac{1}{\beta_2 \nu_t} \left[ 1 + \beta_1 p_t + \beta_2 \mu_t \right] \quad (2.14)
\]

Therefore, by dividing both sides of 2.14 by \( \beta_2 \), subtracting \( \ln M \), and adding \( \mu_t \) and finally dividing by \( \nu_t \) yields

\[
E_t(y) = \Phi \left[ \frac{1}{\beta_2 \nu_t} \left( 1 + \beta_1 p_t + \beta_2 \mu_t \right) \right] \quad (2.15)
\]

where \( E_t(y) \) is the fraction of individuals purchasing the product and \( \Phi(.) \) is the univariate normal cumulative distribution function and \( \mu_t \) is the mean of log income. By using the log normal assumption, the above equation can be written in terms of mean income \( E_t(M) \) as follows:

\[
E_t = \exp \left[ \mu_t + \left( \frac{1}{2} \right) \nu_t^2 \right]
\]

By solving this for \( \mu_t \) and substituting it back into 2.15 yields the aggregate model as follows:
\[ E_t(y) = \Phi \left[ \frac{1}{\beta_2 v_t} \left( 1 + \beta_1 \ln p_t + \beta_2 \ln E_t(M) - \beta_2 \frac{v_t^2}{2} \right) \right] \] (2.16)

With observation on \( E_t(y), E_t(M) \), and \( v_t \) over time \( t \), the individual level parameters can be estimated. Thus Stoker (1993) has illustrated how aggregate models can be formulated with nonlinear individual models, and how the behavioral parameters are recoverable from the aggregate model. With respect to nonlinear models his conclusions were: (i) without such a recoverability property, there is no clear connection between the two levels; (ii) linear individual models are the only models that give recoverability for a broad range of distributions; and (iii) there are classes of distributional restricted where recoverability is assured regardless of the form of the individual behavioral model (linear or nonlinear).

Chambers (1988) considered nonlinear aggregation through the cost of production. He postulated the aggregate cost function to be \( C(W, Y) \) and the individual cost function to be \( C^i(W, y^i) \), where \( y^i \) is output for the \( i^{th} \) firm. For consistent aggregation, it is required that aggregate cost be the sum of all firm's costs \( [C(W, Y) = \sum_i C^i(W, Y)] \) and that aggregate output be functionally related to firm output \( Y = Y(y^1, ..., y^m) \). The sufficient conditions for this aggregation rule to be satisfied are

\[
C(W, Y) = \lambda(W)Y + \lambda^*(W) \\
C^i(W, Y) = \lambda(W)h^i(y^i) + \lambda^i(W)
\]

where \( Y = \sum_i h^i(y^i) \) and \( \lambda^*(W) = \sum \lambda^i(W) \) (Gorman, 1968). Chambers stated that each firm-level cost function is quasi-homothetic but with an important difference: marginal cost is not identical across all firms, and is not independent of firm-level output. For this case Chambers came up with the following results. These were: (i) marginal cost is not
constant either for the aggregate function or the individual firms and (ii) homothetic production structures can be represented without forcing the imposition of a constant-returns technology. He mentioned that it is possible to aggregate different technologies across individuals because both \( h^i(y^i) \) and \( \lambda^i(W) \) can vary across individuals.

Stoker (1984a) analyzed the problem of aggregation over individual agents with special emphasis on nonlinear micro behavior and the role of the distribution of predictor variables across agents. He provided the required theoretical foundation for this purpose as a complete aggregation structure in which a unique correspondence between micro functions and aggregate functions. He mentioned that the unique advantage of a complete aggregation approach is that it provides a general framework for incorporating nonlinear microeconomics behavior and specific restrictions on the predict variables. Here completeness means a particular aggregate function is associated with a unique for of micro function. He illustrated this approach through a number of examples such as: (i) linear micro functions; (ii) quadratic micro functions; (iii) probit micro functions.

Taylor (1983) considered the aggregation over individuals through a single-period, \( z \)-variable factor, quadratic production function. He derived the product supply and the factor demand equations and then aggregated them over all firms.

Assumptions include: (1) a quadratic production function that is a second-order approximation to any function; (2) all firms face the same prices: and (3) inputs and outputs are homogeneous.

His model may be represented as:

\[
 y_i = a_0 + a_1 x_{1i} + a_2 x_{2i} + 1/2b_1 x_{1i}^2 + 1/2b_2 x_{2i}^2 + b_3 x_{1i} x_{2i} \tag{2.17}
\]
where $y_i$ is output for the $i^{th}$ firm and $x_{li}$ and $x_{2i}$ are factors of production. Under the assumption of profit maximization, the associated product supply equation and factor demand equations are:

$$y_i^* = g_{0i} + 1/2 b_{1i} \left( \frac{r_1}{p} \right)^2 + 1/ 2 b_{2i} \left( \frac{r_2}{p} \right)^2 + b_{3i} \left( \frac{r_1}{p} \right) \left( \frac{r_2}{p} \right)$$

$$x_{1i}^* = h_{1i} + b_{1i} \left( \frac{r_1}{p} \right) + b_{3i} \left( \frac{r_2}{p} \right)$$

$$x_{2i}^* = h_{2i} + b_{3i} \left( \frac{r_1}{p} \right) + b_{2i} \left( \frac{r_2}{p} \right)$$

(2.18)

where $r_1$ and $r_2$ are factor prices, $p$ is product price, and $g_{0i}$, $b_{ji}$ and $h_{ki}$ are related to the parameters of equation (2.17)). Based on the above assumptions, supply and factor demand equations in (2.18) can be aggregated without bias (Taylor, 1983):

$$y_i^* = g_{0i} + 1/2 b_{1i} \left( \frac{r_1}{p} \right)^2 + 1/ 2 b_{2i} \left( \frac{r_2}{p} \right)^2 + b_{3i} \left( \frac{r_1}{p} \right) \left( \frac{r_2}{p} \right).$$

$$x_{1i}^* = h_{1i} + b_{1i} \left( \frac{r_1}{p} \right) + b_{3i} \left( \frac{r_2}{p} \right).$$

$$x_{2i}^* = h_{2i} + b_{3i} \left( \frac{r_1}{p} \right) + b_{2i} \left( \frac{r_2}{p} \right).$$

(2.19)

where dots represent summation over all firms.

Thus, if these assumptions are valid, aggregate product supply and factor demand equations can be estimated from aggregate time series data without bias. Equation set (2.18) and (2.19) are useful for highlighting potential micro/macron model specification complementarities. If we had a macroeconometric-simulation model based on (2.19) along with product demand and factor supply equations, the macro-model could be used to simulate certain types of policies. Then, price impacts obtained from the macro-model
could be used in representative firm models. equation set (2.18), to estimate distributional impacts. Thus, the macro- and micro-model results would be consistent (Taylor, 1983).

Stoker (1993) pointed out that every model that accounts for aggregation over individuals must begin with a specification of individual behavior. With regard to studying aggregate supply the first step is to model the individual supply functions, \( q_{it} = f_i(p_t, w_t) \), for each individual producer. In turn, this requires identifying the individual differences that affect individual supply. The differences can be denoted compactly as \( D_{it} \), and the common individual supply function can be rewritten as:

\[
q_{it} = f_i(p_t, w_t, D_{it}),
\]

where \( D_{it} \) varies over individuals, and \( p_t \) and \( w_t \) are the prices of output and inputs, respectively. The "model" for aggregate supply \( q_t \) then can be written as

\[
q_t = \frac{1}{N_t} \sum_{i=1}^{N_t} f(p_t, w_t, D_{it})
\]

In this approach, exact aggregation or related linear methods based on restrictions of the form of \( f(.) \) can be used to structure the above model.

2.4.3 From Micro-Level to Macro-Level Supply Response

Previous modeling efforts directed toward policy evaluation have tended to focus on either the micro-system (the firm) or on the macro-system (the aggregate). Separating these approaches has not proven entirely satisfactory for policy analyses (Taylor, 1983), in part because of: (1) invalid estimates from micro-models attributable to assumptions that some aggregate variables, such as price, remain unaffected when in fact they are affected by the resulting behavior of the sector as a whole; (2) macro-models' lack of structural specification or flexibility to estimate distribution impacts; and (3) macro-model results often being invalid because of possible aggregation or composition bias. Specifically, aggregate functions derived from individual firm-level relationships did not
approximate well the aggregate functions based on aggregate data. Ultimately, researchers moved away from this kind of approach because of problems of aggregation. Consequently, the motivation for doing this study is the perceived need for a quantitative and qualitative framework to work at both levels and to ensure consistency between them.

Taylor (1983) discussed the micro- and macro-model complementarities from several definitional perspectives such as model specification, model results and quantitative modeling techniques. He concluded that a complementary micro/macro-model specification is the key to eliminating inconsistent results.

Moschini (1989) outlined the issues to be addressed in this context as (1) the number and possible diversity of the farms comprising the industry, (2) the possibility of entry and exit into and from the industry (at least in the long run), and (3) the possible endogeneity of some prices at the industry level.

It is well known that a competitive industry with freedom to exit and all input prices being exogenously given has a perfectly elastic long-run supply curve (Diewert, 1980). An upward-sloping supply curve for the industry can be explained by assuming that at least one input has less than perfectly elastic supply (as in Hughes, 1980) or that the industry has inframarginal firms.

Moschini, following Hughes (1980), derived the long-run equilibrium of the firm and the industry as follows: He assumed: (1) that one input is not in perfectly elastic supply; (2) that the supply of this input is given by \( g(w_j) \); and (3) that there are \( N \) identical farms in the industry.

Moschini's micro-model was:

\[
P - \frac{\partial C(Y,W)}{\partial Y} = 0 \tag{2.20}
\]
\[ N x_j(Y, W) - g(w_j) = 0 \]  \hspace{1cm} (2.21)

\[ P Y - C(Y, W) = 0 \]  \hspace{1cm} (2.22)

Equation (1) is the individual farm profit maximization condition. Equation (2.21) equates total demand for the scarce input to supply (where \( x_j(Y, W) \) denotes the conditional demand for \( x_j \) of an individual farm), and Equation (2.18) ensures the long-run situation. Equations (2.20) through (2.21) can be solved for the long-run equilibrium \( Y^* \) (the optimal farm output), \( N^* \) (the optimal number of farms), and \( w^*_j \) (the equilibrium price of the \( j^{th} \) input).

His macro-model was represented by an industry equilibrium supply which was defined as:

\[ Y^* = N^* y^* \]  \hspace{1cm} (2.23)

It follows that the own-price elasticity of equilibrium aggregate supply is

\[ \varepsilon_{YP} \equiv \left( \frac{\partial Y^*}{\partial P} \right) \left( \frac{P}{Y^*} \right) \]

This can be utilized to make inference about the industry supply response.

Thus far, this literature review has focused on the specification of supply response considering the question of consistency between the micro and macro levels. The main reason for being concerned with this issue is for analysis of the aggregate effects of government policy which operates according to rules which apply at the level of the individual farmer. In the next section the literature which relates to the subsequent section will be reviewed (Section 2.6), is a discussion of the evaluation of Canadian agricultural stabilization programs. As we shall see, Canadian agricultural stabilization policy has evolved over time from commodity-specific programs to income stabilization
programs which operate according to rules that operate at the individual producer level. Aggregate policy analysis of commodity-based programs can generally be conducted just at the aggregate level, say using aggregate supply and demand functions. However, it is suggested, the aggregate policy analysis of the more recent individual-based stabilization program requires a new methodology along the lines proposed in this thesis.

2.5 Theoretical Approaches to Estimating the Effects of Government Programs on Agricultural Supply

The primary objective of government programs has been to protect producers from the short-term lows in the market that yield returns below the costs of production. The implementation of government programs has always been accompanied by debate over the most effective method of stabilization. Gray et al. (1991), among others, argue that programs offering stabilization stimulate production and also favor production of some crops over others. Production-neutrality of programs has become a particularly sensitive issue in light of the trade-distorting effects of support programs.

In this section the recent theoretical approaches to estimating the effects of government programs on agricultural supply will be reviewed.

Typical acreage response analysis at the aggregate level has started with the framework outlined by Houck and Ryan (1972). Planted acreage is hypothesized to be a function of government programs, expected market conditions and other exogenous variables.

Wayne and Garcia (1994) employed an empirical model to investigate the acreage response at the aggregate level versus disaggregate level. They concluded that modeling acreage response at the aggregate level, rather than at the disaggregate level, leads to little loss in predictive accuracy and provides parameter estimates more consistent with
expectations. Their empirical model consisted of two acreage equations: one for corn and one for soybeans. Desired crop acreage as a dependent variable was assumed to be a function of the relative conditional expected price of corn (RCPC), the relative futures price of soybeans (RFPS), the effective diversion payment for corn (DPC), income risk (RISK) and a dummy variable for the 1983 PIK program (DV83). They suggested a measure of risk in terms of yield variability as follows:

\[
RISK_t = \frac{(RC_t - 1 - MAC_t)^2}{MAC_t},
\]

where \( MAC_t = \frac{(RC_{t-2} + RC_{t-3} + RC_{t-4})}{3} \), and \( RC_t \) is the seasonal average corn price received by farmers in year \( t \) times the average corn yield in the same year. Wayne and Garcia developed a system of two seemingly unrelated regressions (SUR). Consequently they derived the reduced-form equations as follows:

\[
AC_t = \alpha_{11} + \alpha_{12}RCPC_t + \alpha_{13}RFPS_t + \alpha_{14}DPC_t + \alpha_{15}RISK_t + \alpha_{16}DV83_t + (1 - \gamma_{11})AC_{t-1} - \gamma_{12}AS_{t-1} + e_{1t}, \tag{2.24}
\]

\[
AS_t = \alpha_{21} + \alpha_{22}RCPC_t + \alpha_{23}RFPS_t + (1 - \gamma_{22})AS_t + e_{2t}. \tag{2.25}
\]

Equations (2.24) and (2.25) were estimated for nine crop reporting districts (the disaggregate level) and SUR estimates of the state-level corn and soybean equations (the aggregate-level). The aggregate explanatory variables were formed by summing the corresponding individual-level variables.

Cahill (1993) developed a theoretical and an empirical model of the EC grain economy to analyze to what extent the compensatory payments from CAP reform are decoupled. He found that the compensatory payments due to price cuts affect the acreage allocation decision of the producer.
His theoretical model was as follows:

\[ Q_i^r = A_i^r Y_i^r \quad i = 1, \ldots, n \ ; r = 1, \ldots, R \quad (2.26) \]

where \( Q_i^r \) is output of crop \( i \) in region \( r \). \( Y_i^r \) is average yield for crop \( i \) in region \( r \). \( A_i^r \) is area planted in crop \( i \) in region \( r \). \( n \) is the number of crops being considered, and \( r \) is the number of a particular production region.

The total differential of (1) yields:

\[ dQ_i^r = dA_i^r Y_i^r + dY_i^r A_i^r \quad (2.27) \]

With the use of (2.26) and (2.27) the average annual output growth rate of crop \( i \) in region \( r \) can be expressed as:

\[ \frac{dQ_i^r}{Q_i^r} = \frac{dA_i^r}{A_i^r} + \frac{dY_i^r}{Y_i^r} \quad (2.28) \]

To obtain the optimal levels of production he defined a revenue function as follows:

\[ H(\tilde{P}, X) = \max_A \left\{ \sum_{i=1}^{n} \tilde{p}_i A_i : X, X \in T^A \right\} \quad (2.29) \]

where \( \tilde{P} \) is a \( l \times n \) vector comprised of elements \( \tilde{p}_i \) = gross revenue/ha = \( p_i Y_i + D_i \). \( p_i \) is the farm-level market price for crop \( i \). \( D_i \) is the compensatory payment for crop \( i \). \( X \) is an input aggregate. \( A \) is a \( l \times n \) vector comprised of elements \( A_i \) = area planted in crop \( i \), and \( T^A \) is the technology set.

The optimal levels to plant to each crop are:

\[ A_i(\tilde{P}, X) = \frac{\partial H(\tilde{P}, X)}{\partial \tilde{p}_i} \quad (2.30) \]

Total differentiation of (2.29), following (2.27) gives:
\[ dA_i(\hat{P}, X) = \sum_{i=1}^{n} \frac{\partial A_i(\hat{P}, X)}{\partial \hat{P}_i} \cdot d\hat{P}_i \] (2.31)

Cahill analyzed supply response and yield response by developing a profit function as follows:

\[ \pi_i(p_i, W_t) = \max_{G_i} \left\{ p_i y_i (G_i(P, W), U(t) - W G_i(P, W)) : A_i, G_i, y_i \in T^Y_i \right\} \] (2.32)

where \( W \) is the price for the input aggregate \( G_i \); \( G_i \) is an aggregate of inputs used to control yield, \( f(z_i) \); \( z_i \) is a 1xq vector of input quantities \( z_{i\tau} \); and \( g_i \) is an aggregation function; \( U(t) \) is a variable representing year-to-year variation in yield not controllable by the producer \( i \); and \( T^Y_i(t) \) is the set of combination of \( G_iY_i \) possible with the technology used at time \( t \). He employed the above model to derive supply response function as follows:

\[ \frac{dQ_i}{Q_i} = \sum_{j=1}^{n} \varepsilon_{ij} A (1 + \varepsilon_{ij} YP) \frac{dp_j}{p_j} + \sum_{j=1}^{n} \varepsilon_{ij} A \frac{dD_j}{p_j} + \sum_{j=1}^{n} \varepsilon_{ij} YP \frac{dt}{t} + \varepsilon_{i} YP \frac{dp_i}{p_i} + \varepsilon_{i} YT \frac{dt}{t} \] (2.33)

From (2.33) he derived the change in output of individual \( i \) as a function of acreage and yield response elasticities as well as the price/compensatory payment changes.

Miranda, Novak and Lerohl (MNL) (1994) estimated a structural acreage supply model for Western Canada. They assumed that farmers based acreage allocation decisions on the ex ante rational expectation and variance of per-acre revenues. They have used a combination of econometric methods and numerical quadrature techniques to estimate a nonlinear rational expectations model of aggregate acreage response in the Canadian prairies. Their model was estimated for the period of 1976-90, during which the Western Grain Stabilization Program (WGSP) was in place. MNL (1994) employed a structural
model to estimate a log-linear aggregate acreage response. The specified the supply function as a function of two arguments: the expected marketing year production-weighted average revenue per hectare and the variance revenue per hectare. Their aggregate acreage supply function was as follows:

\[
\log A_t = \alpha_0 + \alpha_1 \log E_t R_t + \alpha_2 \log V_t R_t + \alpha_3 \log A_{t-1}^* + \epsilon_t \tag{2.34}
\]

where \( A_t \) is millions of hectares planted in western Canada, \( R_t \) is the production weighted average revenue per hectare, \( E_t \) and \( V_t \) are the expectation and variance operators conditional on the planting-time, and \( A_{t-1}^* \) is the millions of tillable hectares available from the previous year.

MNL (1994) performed two submodels to determine the acreage response for western Canada. The first model consisted of four grain market equations defining production, marketing, yield, and stock supplies. The second sub-model calculated payment schemes for the WGSP. They modified Taylor-Fair's procedure, for estimation the above equation, consisted of three steps. Maximum likelihood was used to estimate the grain market sub-model and the Gauss-Hermite numerical integration techniques was employed to compute the rational ex ante sub-expectations and variance of per hectare revenues. Finally they applied Ordinary Least Square (OLS) to the second step results to estimate the above equation. MLN found that the short run elasticity of acreage supply with respect to expected per-hectare revenue was approximately 0.28 and the short-run elasticity of acreage supply with respect to revenue variance was approximately -0.08. They did not include input prices in their model. This is one of the major shortcomings which may lead to bias estimation.

The present study for the purpose of a methodological illustration will use these elasticity to derive an aggregate acreage supply function for Saskatchewan.
Love (1988) began his theoretical model for grain supply with government programs by exploring in detail the choices each individual farmer must make when deciding how much of which crops to produce. At planting time, a farmer must decide, given his resource constraint; (1) whether to participate in any government programs that are offered; (2) the number of acres of each crop to plant; and (3) what level of variable inputs to use on each acre of land planted.

Furthermore, the decision to participate in government programs imposes additional constraints on the farmer's actions. In making this set of decisions, a farmer must determine the optimal input decisions for land and variable inputs for both compliance and noncompliance with government programs, and then must evaluate which of these options is most profitable.

Love (1988) in a US study created a flexible public policy model in which farmers make their choices when risk neutrality was assumed. His model was:

$$\max_{a,y,\delta,d} \delta(E(\pi_n)) + (1-\delta)(E(\pi_c))$$

(2.35)

where $\pi_c$ is profit from compliance with government programs. $\pi_n$ is profit from noncompliance. $\delta$ is a 0/1 variable where 1 represents compliance decision. 0 indicates noncompliance. $y$ is a vector of per acre yields. $a$ is a diagonal matrix of percentages of acreage participating for each crop, and $d$ is a vector of voluntary additional acreage diverted. The farmer chooses not to participate or to participate based on his maximized profits from each option. Participation profits are the sum of deficiency payments support, profits from participation in Commodity Credit Corporation (CCC) nonresource loan program less costs plus paid land diversions and additional paid land diversion. This is subject to a land constraint, a program acreage constraint, diverted acreage constraint, and the market price mechanism.
Love found an expression for the constrained maximum of Equation (2.35) and derived the first order conditions. He substituted the first order conditions back into Equation (2.35), and found the optimal choice for acreage and yield of each crop for each farmer. He then aggregated acreage and yield response equations by summing the individual acreage decisions and yield decisions over all farmers.

Massow and Weersink (1993) developed a supply response function under uncertainty from the utility maximization principles to assess the impact of government support programs on acreage response in white beans, corn, soybeans and winter wheat in Ontario. They incorporated the truncation effects of government support programs on the expectation and variance of crop revenues. Their approach was to represent the net revenue which is generated from crop revenue subject to total acreage and the farm household budget:

\[
R = \sum_{i=1}^{n} \left( p_i y_i - c_i \right) A_i
\]  

(2.36)

\[
A_T \geq \sum_{i=1}^{n} A_i
\]  

(2.37)

\[
W + \sum_{i=1}^{n} \left( p_i y_i - c_i \right) A_i = PG
\]  

(2.38)

where \( A_i \) is the acreage assigned to the \( i \)th crop, \( y_i \) is the yield, \( p_i \) is the price for crop \( i \), \( c_i \) is the per-acre production costs, \( R \) is the net revenue generated from crop revenue, \( A_T \) is the total land available, \( W \) is the initial wealth, and \( P \) is an index of prices for the consumption goods, \( G \).

Given this basic model the authors formulated the optimization problem as follows:
\[
\max_A EU \left( I + \sum_{i=1}^{n} \pi_i A_i \right)
\]  
(2.39)

such that:

\[
\sum_{i=1}^{n} A_i \leq A_T
\]

where \( I \) is the normalized initial wealth and \( \pi_i \) is the normalized profit per acre for the \( i \)th crop.

Massow and Weersink solved the above problem for the optimal acreage response function, which is represented as

\[
A_i^* = f(I, \pi_1, \pi_2, \ldots, \pi_n; \Omega)
\]  
(2.40)

where \( \Omega \) is the subjective expectations of the higher moments of the net return distributions.

They discussed the nature of risk preferences in their model. They indicated that if the derivative of the acreage response function with respect to wealth and the higher-order moments of the random variables were equal to zero then this would imply risk neutrality:

\[
\frac{\partial A_i}{\partial I} = 0, \frac{\partial A_i}{\partial \Omega} = 0
\]  
(2.41)

They pointed out that if the first term in the above equation (2.25) is nonzero, the producer is exhibiting a risk response to acreage allocation due to a change in the wealth endowment which implies nonconstant absolute risk aversion.

Based on the above theoretical framework they developed a truncated expectations model to measure how GRIP and the National Tripartite Stabilization
Program (NTSP) affected the acreage of white beans, corn, soybeans and winter wheat. Their findings indicate that the NTSP dramatically boosted white bean acreage while the Agricultural Stabilization Act increased corn plantings at the expenses of a portfolio of alternatives. The GRIP, which provides a consistent measure of support to all crops, provided the least potential for reallocation of land among crops.

Horbulyk (1993) developed a theoretical model to examine the optimal supply response of individual firms to a participatory stabilization scheme such as the NTSP. His model assumed: (1) that the representative agent is a risk-neutral firm that views output price as a random variable; (2) that there is a nonrandom production function $q = f(K,L)$, where $K$ denotes capital and $L$ denotes labor; (3) that there is a random output price, such that $p \sim F(p)$, where $F(p)$ is the cumulative distribution function of $p$; and (4) that input prices $(w,c)$ and production technology are known.

His model of the individual firm's problem was:

$$\begin{align*}
\text{Max: } & E[\pi(f(K,L))]
\{K,L\} \\
= & E[(P + S)f(K,L) - wL - cK]
\end{align*}$$

where $S$ is the net payment or benefit per unit of output, $L$ is labor, $K$ is capital, $W$ is labor price, $C$ is capital price, and $P$ is market price for output. Horbulyk pointed out that the firm that chooses to enroll in a participatory stabilization scheme then pays a premium, say $R$, per unit of output for the entire participation period. In return, the firm receives a deficiency payment per unit of output for any output sold when the market price, $p$, is below the support price, $p_s$.

Under such a scheme, the net payment, $S$, is defined as:

$$S = \begin{cases} 
(P_s - P) - R & \forall p \in (0, P_s) \\
0 - R & \forall p \in [P_s, \infty)
\end{cases}$$
The first-order conditions of the above model give the optimal choice of $K$ and $L$ in the presence of a stabilization scheme that provides the net payment $S$.

2.6 A Review of Canadian Agricultural Programs

Agricultural production in Canada is affected by market conditions such as international supply-demand factors and natural forces such as weather that cause income variability for farmers. Variability of farmers' income affects their production decisions and causes inefficient resource allocation, and results in a loss to the whole society. As a result, during the last two decades, federal and provincial governments have implemented several agricultural policies that aim to reduce production and marketing risks and to stabilize farm income. Intervention has been at both the federal and provincial level and has been for the most part in the form of commodity-based legislation. As will be shown in this section, the Canadian income safety net system is undergoing a major change from commodity-based schemes to whole farm type programs. Fiscal budgetary constraints and trade implications of agricultural support are factors which have led to serious reconsideration of the way in which governments intervene in agriculture. The implications of this change for the methodology of analyzing the aggregate effects of government support are profound. It means that the earlier, purely aggregate, approaches along the lines of Houck and Ryan (1972) are no longer appropriate. Such approaches were appropriate when the support programs involved commodity-based price supports. However, the new type of income supports involve policy rules that operate at the individual farm. Hence, it is necessary to work at both the aggregate and individual levels and to ensure consistency between them.

The Federal Minister of Agriculture has supported a whole-farm approach to income stabilization which allows for all commodities to be under a single program. The main objective of this section is to demonstrate that policy has evolved to whole farm type programs and this likely to be the trend of the future. Consequently, the motivation
for doing this study is the perceived need to develop an appropriate methodology to analyzed aggregate impacts of the whole farm type programs.

In this section, two forms of price/income stabilization, namely commodity-specific schemes and whole-farm schemes are reviewed.

2.6.1 Commodity Specific Schemes

Spriggs and Van Kooten (1988) state that the three major objectives for these programs were: (1) to stabilize prices and income for farmers; (2) to stabilize farmers' income through higher prices, lower costs or expanding sales; and (3) to meet the implicit political and social objectives. They pointed out that these programs buffered the farmer against a fall in commodity price or income by supporting the commodity-specific price or revenue. These programs were financed by government contribution or government and farmer contribution through regular premiums, which the Crop Insurance Program, Western Grain Stabilization Act, National Tripartite Stabilization Program and Gross Revenue Insurance Program. The next few pages will review these programs in more detail.

(i) Crop Insurance Program

In 1959, the federal government passed the Crop Insurance Act. The Crop Insurance Program became operational in 1961 and was intended to reduce instability in farmers' returns for losses caused by natural hazards. The program covers wheat, oats, flax, canola, barley, rye, sunflower seeds, mustard, utility wheat, field peas, lentils and canary seed. This program provided for the payment of federal contributions to provincial crop insurance schemes.

Crop insurance is a cost-shared program between the producers, the provincial government and the federal government. The federal government and the producers
equally share the cost of the programs while the provincial government covers the administration cost.

The major effect of this program was to reduce the uncertainty associated with the production of grains and other crops in Canada. The program was a yield insurance approach, and it cannot stabilize the uncertainty in farmers' income caused by the world market price variation. Two significant features of the program are: (1) shared financial responsibility of the federal and the provincial governments; and (2) the goal of income stability instead of yield risk reduction. These two features have been characteristic of much of the agricultural policy in the last two decades.

(ii) Western Grain Stabilization Act

The Western Grain Stabilization Act (WGSA) was introduced in 1976 to stabilize income from major grains in the Prairies. The goal of the program was to avoid uncertainty in the net cash flow to farmers, caused by the international market. The program was based on contributions from producers and the federal government. Until 1986/87 farmers contributed from 1 to 2 percent of their total gross sales to the program. The eligible crops under this program were wheat, oats, barley, rye, flax, canola and mustard. The WGSA was a support program. When the net cash flow from these grains fell below the average of the previous five years, then the program generated payouts.

The large payments to farmers after the crop year 1983/84 created a deficit in the WGSA fund. As a result, in 1988, the government modified the program. Under the new legislation producers' contributions range from 2 percent to 4 percent of their total gross sales. The federal government now had to contribute an amount equal to the producers' levy plus 2 percent. Despite the increase in the producers's levy, other modifications of the WGSA had a negative effect on the programs' funds.
The WGSAs were designed to stabilize aggregate income for the industry rather than the income of individual producers, so it did not really offer income stabilization to the individual producer (Van Kooten et al., 1989). A number of studies have been conducted to address the Western Canadian acreage response under the WGSAs (e.g., Coyle and Brink, 1990; Meilke and Weersink, 1990; Cameron and Spriggs, 1991; and Miranda, Novak and Lerohl, 1994). These studies employed reduced form of expectations models.

The WGSAs and the Crop Insurance were replaced by the Gross Revenue Insurance Plan (GRIP).

(iii) National Tripartite Stabilization Program

The National Tripartite Stabilization Program (NTSP) was jointly supported by the provincial and federal governments. This was a voluntary insurance plan designed to enable those producers who choose to join to improve the stability of their income. The support level was varied depending on the commodity covered. The programs were designed to be actuarially sound, contributions being equally shared by the federal government, the provincial government and producers. Research has indicated that the effectiveness of NTSP for livestock was considerably eroded under countervail (Meilke and Terpstra, 1993).

(iv) Gross Revenue Insurance Program

The Gross Revenue Insurance Program (GRIP) was one of the programs under the Farm Income Protection Act, which was passed into law in 1991. GRIP offers a degree of income stabilization for grain producers. This program contained two major components, revenue protection and crop insurance. Producers may choose either component or both depending on their individual needs. The payment under this program was calculated by
subtracting the market value of the grain produced and the maximum available crop insurance indemnities from target revenue.

The program was jointly funded by the federal government, the provincial government, and producers. In 1991, it replaced the Western Grain Stabilization Act and crop insurance. GRIP's goals were to provide farmers with revenue protection. The program was administered by the provincial crop insurance agency. This program was recently terminated in Saskatchewan and replaced by an enhancement to another program (NISA) which is discussed in the next section and by a sector assistance program.

All of these commodity-specific programs established a support price that was compared to the current average market price. If the support price was above the market price, the participants received the difference as a deficiency payment. Spriggs and Van Kooten (1988) pointed out that, in most cases, the contributions were either a percentage of the value of marketing's or a percentage of the volume of marketing's. In all programs, the federal or provincial government contributed to the price support. Spriggs and Van Kooten indicated that, since all of these programs involved government contributions, these programs were not only stabilization programs but also subsidy programs in the long-run.

The income safety net system for Saskatchewan agriculture is undergoing major change from commodity-specific schemes to whole farm type schemes. In the 1993 budget, Saskatchewan gave notice of its intention to withdraw from the GRIP after the 1994/95 crop year. The income safety net for the livestock sector, the NTSP, has been discontinued. Fiscal budgetary constraints and trade implications of agricultural support are factors which have led to serious reconsideration of the way in which governments intervene in agriculture. Participation in the Net Income Stabilization Account (NISA) program is currently scheduled to continue. The Federal Minister of Agriculture has
supported a whole farm type approach to income stabilization which allow for all commodities to be under a single program. In the following sub-section the whole farm type programs will be reviewed.

2.6.2 Whole Farm Schemes

The income safety net system for Saskatchewan agriculture is undergoing major change. In the 1993 budget, Saskatchewan gave notice of its intention to withdraw from the GRIP after the 1994/95 crop year. Participation in the Net Income Stabilization Account (NISA) program is currently scheduled to continue. NISA is regarded as a whole farm type program. In this sub-section these programs will be described in more detailed.

(i) *Net Income Stabilization Account*

The Net Income Stabilization Account (NISA) is an individual stabilization account to which the farmer makes annual deposits and, if triggered, can make withdrawals. Any individual who reported sales of eligible farm commodities of any amount for Canadian income tax purposes is eligible to set up a NISA.

The producer can deposit matchable contributions up to 2% of eligible net sales up to a maximum of $250,000 in sales, which works out to $5,000 of contributions. Eligible net sales are defined as gross farm sales from qualifying commodities less purchases of all agricultural commodities such as feed and seed. Qualifying commodities include most grain, oilseed, specialty crops, edible horticultural crops and farm-fed grain for cattle livestock. The federal and provincial governments together make a combined, matching deposit; that is, a 1% contribution from the federal government and 1% from the provincial government. In addition, farmers are entitled to make additional deposits which would not be matched by government deposits, to a maximum of 20% of eligible net sales. It is important to note that all farmer deposits are made with after-tax dollars. Any income earned in the NISA account is tax differed until it is withdraw.
NISA is divided into two separate funds, a producer fund and a government fund. Government deposits receive a market rate of interest which is determined by current Treasury Bill rates. The governments provide an interest bonus of three percent on all producer matchable deposits. Withdrawals are taken from the governments' fund first and then from the producer fund. Withdrawals from the government fund are taxable; withdrawals from the producer fund are not. The primary objective of NISA is the stabilization of farm income over time. However, it appears that many farmers are using NISA as a retirement saving account.

(ii) Value Added Income Stabilization Account

Value added is defined as returns to land, labor, capital and management. VAISA is essentially a proposed modification of NISA, using a value-added measure rather than eligible net sales, as a basis for determining contributions. For the purposes of this proposed program value added is defined as net farm income (profits) plus: wages paid, rent paid, net property taxes paid, interest paid, and capital cost allowance and allowance in eligible capital property.

Withdrawals under VAISA are triggered if the current year gross value added falls below its 5-year moving average. A withdrawal is also triggered if total income falls below $10,000. Under the first trigger, withdrawals are limited to the difference between the current gross value added and the 5-year average but the account balance cannot go into deficit.

2.7 Summary

A substantial literature has evolved on modeling supply response with respect to policy variables with risk and without risk. These modeling efforts, which were directed toward policy evaluation, have tended to focus on either the individual level (the micro-
system) or on the aggregate level (the macro-system) separately. Separating these approaches has not proven entirely satisfactory for policy analyses. Aggregation functions derived from individual firm-level relationships did not approximate adequately the aggregate functions based on aggregate data. More recently, Stoker (1994) has suggested an alternative approach to the aggregation problem that starts with an estimated aggregate function, and from this derives individual-level functions that are consistent with the aggregate level function.

Government intervention in Canadian agricultural markets to stabilize commodity prices and producer incomes has had a long tradition. Intervention has been at both the federal and provincial level and has been for the most part in the form of commodity-based schemes. The main objective of these programs was to correct market failures. Spriggs and Van Kooten (1988) indicated that, since all of these programs involved government contributions, these programs were not only stabilization programs but also subsidy programs in the long-run. They pointed out that the commodity-based programs are not an appropriate form of intervention. More recently the Federal Ministry of Agriculture supported a whole-farm approach to income stabilization that would allow for all commodities to be under a single program. The basic NISA can be regarded as a whole-farm income support program, and potentially a prototype for the next generation of agricultural income stabilization programs in Canada. The implications of this change for the methodology of analyzing the aggregate effects of government support are profound. It means that the earlier, purely aggregate, approaches along the lines of Houck and Ryan (1972) are no longer appropriate. Such approaches were appropriate when the support programs involved commodity-based price supports. However, the new type of income supports involve policy rules that operate at the individual farm. Hence, this will be used in an empirical analysis to illustrate the aggregation methodology that will be developed in chapter 4.
The main objective of this thesis is to develop an appropriate methodological approach that permits individual data and the aggregate response to be modeled under one consistent framework. In particular, an individual model will be specified together with assumptions that permit an aggregate model to be formulated that will be consistent with the individual model. The secondary objective is to apply this methodology to farm-level data and the basic NISA program in Saskatchewan as an illustration of how one might estimate the aggregate effects of such a policy.
CHAPTER 3

METHODOLOGY OF ANALYSIS

3.1 Introduction

The purpose of this chapter is to develop the methodology for analyzing the effects of policy on supply at the aggregate level when the policy impacts directly at the individual level.

From a methodological perspective, price supports can be analyzed solely by reference to aggregate data, generally using aggregate supply and demand curves. This is not possible with whole-farm income support programs, where policy rules on contributions and withdrawals operate at the individual farm level. Methodologically, work needs to be completed at both the aggregate and individual-farm level and ensure consistency between the two. The objective is to analyze the aggregate effects of such a policy where policy rules operate at the individual level.

Previous attempts at assessing aggregate policy effects based on analysis of individual farms include a large body of work carried out in the 1950s and 1960s, which is summarized by Sharples (1969). Ultimately, researchers moved away from this kind of approach because of problems of aggregation. Aggregation functions derived from individual firm-level relationships did not approximate adequately the aggregate functions based on aggregate data. More recently, Stoker (1994) has suggested an alternative approach to the aggregation problem that starts with an estimated aggregate function, and from this derives individual-level functions that are consistent with the aggregate level function. Policy analysis is performed on these individual-level relationships and then the individual data are summed to achieve the aggregate-level effects. There have been few empirical attempts at using this general methodology but they include the Joint

Three specific methodological objectives are addressed in this chapter:

1. Estimation of individual representative supply functions that are consistent with an aggregate supply function.
2. Simulation of the policy effects at the individual and aggregate levels.
3. Aggregation of the simulated policy effects to the provincial level.

These problems are discussed in sections 3.2, 3.3, and 3.4 respectively.

3.2 Estimation of Farm-Level Supply Functions

The purpose of this section is to discuss the major issues involved in forming and estimating a system of individual-level supply functions based on an estimated aggregate supply function, where the basic model is specified at the individual level. This section begins with a discussion of previous attempts at dealing with three major issues—consistency, aggregation bias, and recoverability—in developing a methodological approach for aggregation over individuals in supply response analysis.

The issues involved in aggregating over individual farms can be explained as follows. Let the individual representative farms (farm type) be indexed by \( i = 1, \ldots, N \), and denote by \( y_i \) the crop area on farm \( i \). According to Miranda, Novak and Lerothl (MNL) (1994), and based on ex ante rational expectation, \( y_i \) is a function of two arguments: the expected revenue and the variance of revenue. MLN used a log-linear acreage supply function but here for the sake of convenience, linear micro and macro acreage supply functions will be used and are specified respectively as:

\[
y_{ik} = a_i + b_i E(m_{ik}) + c_i \text{ var}(m_{ik}) \quad \text{where} \quad k = 1, \ldots, K
\]

\[Y = a + b E(M) + c \text{ var}(M)\]
where:
\( y_{ik} \) is the area planted on farm type i in crop district (CD) k, \( m_{ik} \) is revenue per acre from operating farm type i in CD k, \( Y \) is the area planted in the whole province.

\( M \) is the weighted average of the revenue per acre from operating all farms for the whole province.

\( E \) and \( var \) are the expectation and variance operators.

For a generic three-variable model, and ignoring crop districts for simplicity, the situation can be represented as in Figure 3.1. Here \( E(m_i) \), \( var(m_i) \), and \( y_i \) are microvariables and \( E(M) \), \( var(M) \), and \( Y \) are the corresponding macrovariables. Dashed lines from micro variables to corresponding macro may represent the functional relations. It can be considered as a micro model in which farm supply is a function of revenue per acre and variance of revenue. By analogy the aggregate supply for all farms is a function of a weighted average of revenue per acre and its variance.

3.2.1 Consistency Criterion

In considering the problem of aggregation over individuals we are interested in the interrelations of three kinds of relations: micro relations, macro relations, and aggregation relations. The key assumption underlying existing analyses of the empirical effects of aggregation is that the macro and micro variables are functionally related, as represented in Figure 3.1.

The problem here is one of ensuring consistency between the aggregate supply function and the individual (representative farm) supply functions used in the analysis of the policy.

Theil (1954) provided the necessary conditions for the macro and micro relations to be consistent. The macro and micro relations are consistent when the distribution of
Microrelations \( y_{it} = a_i + b_i E(m_{it}) + c_i \text{var}(m_{it}) \)

\( E(m_{it}) \)

\( \text{var}(m_{it}) \)

Aggregation relations

MACRORELATIONS

Macroleations \( Y_t = a + b E(M_t) + c \text{var}(M_t) \)

\( E(M_t) \)

\( \text{var}(M_t) \)

Figure 3.1. Micro and macro relations in aggregation process.
regressors across micro units is stable over time. When this occurs, estimated macro coefficients are averages of corresponding micro coefficients weighted according to the fixed distributions.

Green also poses the problem as follows:

"Consistency means that a knowledge of the "macro-relation"... and of the values of the aggregate independent variables would lead to the same value of the aggregate dependent variable as a knowledge of the micro relations and the values of the individual independent variables" (Green, 1964, p.35).

This definition suggests that we need to ensure consistency between two different methods for generating predicted values of the dependent macrovariable. The first method is direct estimation of the macro function. Suppose we denote a resulting predicted value as \( Y_1 \). The second method involves estimation of the micro functions for each micro-unit to obtain predicted values for \( Y_i \) and then apply the aggregation relation to these predicted dependent micro variable values to generate a predicted macro value, which we denote as \( Y_2 \). Following Green's definition, we will say that aggregation in this model is consistent if and only if \( Y_1 = Y_2 \). If this equality does not hold, the difference \( Y_2 - Y_1 \) is said to be due to the presence of aggregation bias in the parameters.

3.2.2 Aggregation Bias in Supply Equation Estimation

This section discusses the situation when, under certain assumptions, there is no aggregation bias; and then presents the case when there is aggregation bias. First, let us assume that all individuals have identical homothetic technology, the same input and output prices, but varying revenue. Under these assumptions, the supply for individual \( i \) at a given point in time can be expressed as,

\[
y_i = b m_i
\]  

(3.1)
where \( y_i \) is the area planted by farm \( i = 1, \ldots, N \) and \( m_i \) is revenue per acre of farm \( i \). Here, an additional dollar of revenue increases supply by \( b \) for any farm. In this case, aggregate supply is

\[
Y = bN M
\]  
(3.2)

where \( Y = \sum y_i \) is the aggregate area planted by the province, \( N \) is the number of farms, and \( M = \sum k_i m_i \) is the weighted average of the \( m_i \) (revenue per acre) for the province. Suppose that revenue per acre changes, by \( \Delta m_i \). Each individual representative farm adjusts its supply according to its common marginal effect \( b \), so aggregate supply changes by the marginal amount \( bN \cdot \Delta M, \) where \( \Delta M = \sum k_i \Delta m_i \). Here the aggregate marginal effect \( bN \) is marginal behavioral response of any individual farm multiplied by the number of farms. This is a special case when micro-coefficients across all farm supply equations are the same. Here there is no "aggregation problem."

Now let us assume that the micro coefficients across all individual farm supply functions are not the same. Furthermore, let us assume that the micro model is given by

\[
y_i = a_i + b_i m_i
\]  
(3.3)

where \( y_i \) is the area planted by farm \( i = 1, \ldots, N \) and \( m_i \) is revenue per acre of farm \( i \). Here, an intercept can be added to the previous case which allows for variation across farms.

The corresponding macro model is

\[
Y = a + b M
\]  
(3.4)
where \( Y \) is aggregate area planted in the province, \( M \) is the weighted average of the \( m_i \) (revenue per acre) for the province, and \( a \) and \( b \) are the corresponding macro parameters for intercept and slope respectively. The question is, how is the aggregation to be done? Aggregate supply is

\[
Y = \sum_i y_i
\]

and summation of (3.3) yields:

\[
Y = \sum_i b_i m_i + \sum_i a_i
\]

which states that the total supply depends on all individual revenues. In this approach the conditions for aggregation are as follows:

\[
Y = a + bM
\]

where

\[
bM = \sum_i b_i m_i
\]

Since \( M = \sum_i k_i m_i \), then

\[
b \sum_i k_i m_i = \sum_i b_i m_i
\]

\[
\sum_i b_k i m_i = \sum_i b_i m_i
\]

\[
bk_i = b_i
\]

\[
b = \frac{b_i}{k_i}
\]

The above conditions show that the exact linear macro-relation can be obtained from the \( N \) micro relations (3.3) and under the above conditions there is no aggregation bias. The macro slope \( b \), the marginal propensity to supply in the aggregate, is a multiple of any individual micro slope \( (b_i) \); and the macro intercept \( (a) \) is the sum of the individual micro intercepts \( (a_i) \).
However, under a more general case, aggregation bias arises, as shown by Theil (1954). Theil’s approach assumes that the macro-relation is a statistical rather than an exact one, and it relates to a specific period of time (say $t=1, \ldots, T$) and not simply to one time point. The following discussion is based on Theil’s approach but it also differs in the defined relationship between the micro- and macro- explanatory variables. Consider the micro relations are

$$y_{it} = a_i + b_i m_{it} + u_{it}, \quad (i=1, \ldots, N, t=1, \ldots, T) \tag{3.5}$$

where $m_{it}$ is revenue per acre of farm type $i$ at time $t$, and $u_{it}$ is a residual term and the macro relation is

$$Y_t = a + b M_t + U_t \tag{3.6}$$

Assume that revenues ($m_{it}$) of different farms may have somewhat different time paths during the period that the macro relation ($M_t$) is to be estimated. These individual time path differences may be expressed as follows:

$$m_{it} = \alpha_i + \beta_i M_t + \varepsilon_{it} \tag{3.7}$$

where $M_t$ is the weighted average of the revenue per acre of province at time $t$ and $\varepsilon_{it}$ is a residual term. Thus, $M_t = \sum_{i} k_{it} m_{it}$ where $k_{it}$ are (average) weights. Multiplying through equation (3.7) by $k_{it}$ and then summing over the $N$ farms it may be seen that the following conditions must hold:

$$\sum_{i} k_{it} \alpha_i = 0; \quad \sum_{i} k_{it} \beta_i = 1; \quad \sum_{i} k_{it} \varepsilon_{it} = 0$$
Summing the N micro relations (3.5) and substituting equation (3.7) into the resulting equation we may obtain the following.

\[
Y_t = \sum a_i + \sum b_i (\alpha_i + \beta_i M_t + \epsilon_i t) + \sum u_i t
\]

\[
Y_t = \left( \sum a_i + \sum b_i \alpha_i \right) + \left( \sum b_i \beta_i \right) M_t + \sum b_i \epsilon_i t + \sum u_i t
\]

which is of the form required for the new macro relation.

\[
Y_t = a' + b' M_t + U_t
\] (3.8)

Therefore, \(a' = \sum a_i + \sum b_i \alpha_i\) and \(b' = \sum b_i \beta_i\), where \(\sum k_i \alpha_i = 0\) and \(\sum k_i \beta_i = 1\).

Hence the slope of the macro relation \(b'\) is a weighted sum of the slopes \(b_i\) of the micro relations, where the weights are \(k_i \beta_i\).

The bias in \(a'\) can be expressed as follows:

\[
a' = \sum a_i + \sum b_i \alpha_i = \sum a_i + N \text{ cov} \left( b_i, k_i \alpha_i \right)
\] (3.9)

where:

\[
\text{cov} \left( b_i, k_i \alpha_i \right) = \frac{1}{N} \sum \left( b_i - \frac{\sum b_i}{N} \right) \left( k_i \alpha_i - \frac{\sum k_i \alpha_i}{N} \right)
\]

Since \(\sum k_i \alpha_i = 0\) then:

\[
\text{cov} \left( b_i, k_i \alpha_i \right) = \frac{1}{N} \sum b_i k_i \alpha_i - \frac{\sum b_i}{N} \sum (k_i \alpha_i)
\]
\[ N \text{cov} \left( \frac{b_i}{k_{it}}, k_{it} \alpha_i \right) = \sum \frac{b_i \cdot k_{it} \alpha_i}{k_{it}} = \sum b_i \alpha_i \]

The bias in \( b' \) can be expressed as follows:

\[ b' = \sum b_i \beta_i = \frac{\sum b_i}{N} + N \text{cov} \left( \frac{b_i}{k_{it}}, k_{it} \beta_i \right) \]

where:

\[ N \text{cov} \left( \frac{b_i}{k_{it}}, k_{it} \beta_i \right) = \sum \left( \frac{b_i}{k_{it}} - \frac{\sum b_i}{N} \right) \left( k_{it} \beta_i - \frac{\sum k_{it} \beta_i}{N} \right) \]

Since \( \sum k_{it} \beta_i = 1 \) then

\[ N \text{cov} \left( \frac{b_i}{k_{it}}, k_{it} \beta_i \right) = \sum \left( \frac{b_i}{k_{it}} - \frac{\sum b_i}{N} \right) \left( k_{it} \beta_i - \frac{1}{N} \right) \]

\[ N \text{cov} \left( \frac{b_i}{k_{it}}, k_{it} \beta_i \right) = \sum \frac{b_i \cdot k_{it} \beta_i}{k_{it}} - \frac{\sum b_i}{N} \sum k_{it} \beta_i - \frac{\sum k_{it}}{N} + N \frac{1}{N} \frac{\sum k_{it}}{N} \]

\[ = \sum \frac{b_i \cdot k_{it} \beta_i}{k_{it}} - \frac{\sum b_i}{N} \]

Therefore, \( \sum b_i \beta_i = \frac{\sum b_i}{N} + N \text{cov} \left( \frac{b_i}{k_{it}}, k_{it} \beta_i \right) \)

These coefficients may also be expressed as follows:
\[ a' = \sum_{i} a_i + N r_{b_i \alpha_i} s_{b_i} s_{\alpha_i} \]
\[ b' = \bar{b} + N r_{b_i \beta_i} s_{b_i} s_{\beta_i} \]

where
\[ \bar{b} = \text{weighted sum of } b_i, \text{ where } \frac{1}{k_{it}} \text{ are the weights.} \]
\[ r_{b_i \alpha_i} = \text{correlation of } \frac{b_i}{k_{it}} \text{ and } k_{it} \alpha_i, \]
\[ r_{b_i \beta_i} = \text{correlation of } \frac{b_i}{k_{it}} \text{ and } k_{it} \beta_i, \]
\[ s_{b_i} = \text{standard deviation of } \frac{b_i}{k_{it}}. \]
\[ s_{\alpha_i} = \text{standard deviation of } k_{it} \alpha_i. \]
\[ s_{\beta_i} = \text{standard deviation of } k_{it} \beta_i. \]

The covariance terms represent the aggregation bias. If the expected revenues of all farmers followed identical time paths (\( \alpha_i = 0 \) and \( \beta_i = 1 \) for all farmers), the covariance terms would be zero since \( s_{\alpha_i} = 0, s_{\beta_i} = 0, \) and \( r_{b_i \alpha_i} = r_{b_i \beta_i} = 0. \) Or, if all farmers had identical marginal effects, \( s_{b_i} = 0 \) and \( r_{b_i \alpha_i} = r_{b_i \beta_i} = 0, \) and the covariances would be zero.

While Theil's approach reveals the source of aggregation bias, it is not helpful in allowing us to recover the coefficients of individual supply functions from an estimated aggregate supply function. This is essential for the purposes of the present thesis. In order to do this, it is necessary to impose additional constraints on the individual supply functions. One approach is to assume complete homogeneity of the individual farms so that the individual supply function is simply \( 1/N \) times the aggregate supply function.
The major problem with this approach is that it does not allow us to examine the
differential effects of the policy on farms of different types in different locations. It can
be noted that consistency of aggregation depends on identical slopes for all micro units
(i.e., they are homogeneous in response to change in explanatory variables in the model
under consideration). The preferred approach is then one of allowing limited
heterogeneity.

3.2.3 Limited Heterogeneity and Recoverability

In this section, the recoverability of micro coefficients for the model of two farm
types, "small" and "large", from the aggregate equation will be discussed by allowing
limited heterogeneity. This will be applied to the models with (i) different slopes; (ii)
different slopes and intercepts; and (iii) different slopes and intercepts and Theil's
approach.

(i) Model with Different Slopes

Within each farm type, producers are assumed to be homogeneous but between
farm types heterogeneity is allowed (Stoker, 1994). Suppose that the only behavioral
differences between these representative farms (RFs) involves the slopes. The new model
for "small" and "large" RFs is as follows:

Supply for the small RFs

\[ y_{1j} = b_1 m_{1j} \quad (j = 1, \ldots, N_1), \]  

(3.11)

and supply for the large RFs

\[ y_{2j} = b_2 m_{2j} \quad (j = N_1 + 1, \ldots, N_1 + N_2). \]  

(3.12)
This type of supply function arises if all small RFs have identical homothetic technologies, all large RFs have identical homothetic technologies, and if the technologies differ between small and large RFs (Stoker, 1994). In this case, the aggregate supply can be specified as

\[ Y = N_1 y_{1j} + N_2 y_{2j} \]
\[ = N_1 (b_1 m_{1j}) + N_2 (b_2 m_{2j}) \]
\[ = (b_1 N_1) m_{1j} + (b_2 N_2) m_{2j} \]  \hspace{1cm} (3.13)

Suppose the aggregate equation is

\[ Y = bM \]  \hspace{1cm} (3.14)

where \( M = \frac{N_1 y_{1j} m_{1j} + N_2 y_{2j} m_{2j}}{N_1 y_{1j} + N_2 y_{2j}} \) and \( b \) is assumed to be known (or estimated).

By substituting \( M \) into (3.14) and rearranging terms, the aggregate equation can be rewritten as follows:

\[ Y = \frac{bN_1 y_{1j}}{N_1 y_{1j} + N_2 y_{2j}} m_{1j} + \frac{bN_2 y_{2j}}{N_1 y_{1j} + N_2 y_{2j}} m_{2j} \]  \hspace{1cm} (3.15)

The conditions for equality of (3.13) and (3.15) are

\[ b_1 N_1 = \frac{bN_1 y_{1j}}{Y} \]  \hspace{1cm} (3.16)
\[ b_2 N_2 = \frac{bN_2 y_{2j}}{Y} \]
Hence, the micro coefficients \( b_1 \) and \( b_2 \) can be recovered from the relations
\[
 b_1 = \frac{b^* y_{1j}}{Y} \quad \text{and} \quad b_2 = \frac{b^* y_{2j}}{Y}.
\]
Thus, if \( b \) is known from the aggregate equation then the micro coefficients \((b_1 \text{ and } b_2)\) can be estimated at the observation means of \( y_{1j}, y_{2j}, \) and \( Y \).

Let us consider the model with different slopes where the differences can be written compactly as a dummy variable. Let \( y_j \) refer to the \( j^{th} \) element of the vector of crop areas of all farms where \( j = 1, \ldots, N_1 + N_2 \) and \( m_j \) refer to \( j^{th} \) element of vector of revenues per acre of all farms where \( j = 1, \ldots, N_1 + N_2 \) and \( N = N_1 + N_2 \). Suppose the differences can be written compactly as \( d_j \), and rearrange the common individual supply functions as \( y_j = f\left(m_j, d_j\right) \). In this case, both \( m_j \) and \( d_j \) vary over individual RFs. The model for aggregate supply is
\[
Y = \frac{1}{N} \sum_j f\left(m_j, d_j\right). \tag{3.17}
\]

To set the ideas of heterogeneity, let "small" and "large" RFs display a different marginal response and let \( d_j \) be a qualitative variable, with \( d_j = 1 \) denoting a small RF and \( d_j = 0 \) denoting a large RF. The basic model (3.11) and (3.12) can be compactly written as
\[
\begin{align*}
  y_j &= b_1 d_j M_j + b_2 \left(1 - d_j\right) M_j \\
  &= b_1 d_j M_j + b_2 M_j - b_2 d_j M_j \\
  &= b_2 M_j + \left(b_1 - b_2 d_j\right) M_j \tag{3.18}
\end{align*}
\]

The aggregate supply model for (3.18) can be written as

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\[ Y = \sum_{j=1}^{N} y_j = b_2 \sum_{j=1}^{N} m_j + (b_1 - b_2) \sum_{j=1}^{N} d_j m_j \]

Since \( \sum_{j=1}^{N} d_j m_j = N_1 m_1 \) then

\[ Y = b_2 [N_1 m_1 + N_2 m_2] + (b_1 - b_2) N_1 m_1 \]

\[ Y = b_2 N_2 m_2 + b_1 N_1 m_1 \]

where \( M = \frac{N_1 y_1 m_{1j} + N_2 y_2 m_{2j}}{N_1 y_1 + N_2 y_2} \) which is equal to \( \frac{N_1 m_1 + N_2 m_2}{N} \) only if \( y_1 = y_2 \).

In this special case then the aggregate supply model can be specified as

\[ Y = (b_2 N) M + (b_1 - b_2) N_1 m_1 \] (3.19)

Here, the form of the individual supply function establishes what distributional information is required, namely \( dM = N_1 m_1 \), as well as how to interpret the aggregate coefficients. In particular, the coefficient of \( M \) is the aggregate marginal effect \( b_2 \) of "large" RFS, and the coefficient of \( dM \) is the difference \( b_1 - b_2 \) of marginal expected revenue response between "small" and "large" RFS.

(ii) Model with Intercepts but the Same Slopes

Now suppose that the only behavioral differences between these farm types involves the intercept. Suppose further that there are \( N_1 \) "small" RFS and \( N_2 \) "large" RFS, and \( P_1 = \frac{N_1}{N} \). \( 1 - P_1 \) denote percentages of "small" and "large" RFS. The new model for "small" and "large" is as follows:
Supply for the "small" RF is
\[ y_{1j} = a_1 + bm_{1j} \quad (j = 1, \ldots, N_1) \] (3.20)

where \( N_1 \) is the number of "small" farms.

Supply for the "large" RF is
\[ y_{2j} = a_2 + bm_{2j} \quad (j = N_1 + 1, \ldots, N_1 + N_2) \] (3.21)

where \( N_2 \) is the number of "large" farms and \( a_1 \) and \( a_2 \) represent the constant terms which are different for these RFs. This form of supply function would arise from quasi-homothetic technologies for each type of RF. By using (3.20) and (3.21) the aggregate supply can be specified as

\[
Y = a_2 + [a_1 - a_2]p_1 + bM \\
Y = a_2 + a_1 p_1 - a_2 p_1 + bM \\
Y = a_1 p_1 + [1 - p_1]a_2 + bM
\] (3.22)

The impact of an additive difference among RFs is to introduce the percentage breakdown of RF types \( p_1 \) into the aggregate equation. The response to a change in revenue per acre at the aggregate level \( M \) remains unchanged: a change in revenue per acre causes a marginal adjustment for every RF in line with \( b \), which matches the aggregate "effect" \( b \). In this case we can estimate aggregate supply and extract all individuals' coefficients from the aggregate equation.

(iii) Model with Different Slopes and Different Intercepts

Suppose that the behavioral differences between the two RFs involve the slopes as well as intercepts. This can be modeled as follows:
Supply for the "small" RFs is

\[ y_{1j} = a_1 + b_1 m_{1j} \]  \hspace{1cm} (3.23)

and supply for the "large" RFs is

\[ y_{2j} = a_2 + b_2 m_{2j} \]  \hspace{1cm} (3.24)

The aggregate supply over the different farm sizes is

\[ Y = y_{1j} N_1 + y_{2j} N_2 \]
\[ = \left( a_1 N_1 + a_2 N_2 \right) + \left( b_1 N_1 m_{1j} + b_2 N_2 m_{2j} \right) \]  \hspace{1cm} (3.25)

\[ Y = a + bM \]  \hspace{1cm} (3.26)

where

\[ M = \left( \frac{y_{1j} N_1}{Y} \right) m_{1j} + \left( \frac{y_{2j} N_2}{Y} \right) m_{2j} \]  \hspace{1cm} (3.27)

\( y_{1j} N_1 \) = total crop area for "small" farms

\( y_{2j} N_2 \) = total crop area for "large" farms

\[ b = \frac{b_1 N_1 m_{1j} + b_2 N_2 m_{2j}}{M} \]  \hspace{1cm} (3.28)

Then, from (3.28) the following equation can be written as:

\[ bM = b_1 N_1 m_{1j} + b_2 N_2 m_{2j} \]  \hspace{1cm} (3.29)

Substituting (3.27) into (3.29) yields:
\[
\begin{align*}
\text{b}\left(\frac{y_{1j}N_1}{Y}\right)m_{1j} + \text{b}\left(\frac{y_{2j}N_2}{Y}\right)m_{2j} &= \text{b}_1N_1m_{1j} + \text{b}_2N_2m_{2j} \\
\end{align*}
\]
(3.30)

From (3.30) micro-coefficients \(b_1\) and \(b_2\) can be recovered as follows:

\[
\begin{align*}
\text{b}_1N_1 &= \text{b}\left(\frac{y_{1j}N_1}{Y}\right) \\
\text{b}_2N_2 &= \text{b}\left(\frac{y_{2j}N_2}{Y}\right).
\end{align*}
\]

(iv) The Multi-Stage Aggregation Problem

One of the problems we need to deal with in the present study is that of multi-stage aggregation. This arises when we have to aggregate first to a CD level (say over farms of different types) and then to a provincial level. To illustrate how to model this situation methodologically, consider the following illustration. Suppose we have a province which consists of two crop districts each with two different farm types ("small" and "large").

Let us assume that the micro model is given by

<table>
<thead>
<tr>
<th>CD</th>
<th>Size</th>
<th>(y_{ij} = a_{ij} + b_{ij}m_{ij})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>(y_{11} = a_{11} + b_{11}m_{11}) (3.31)</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>(y_{12} = a_{12} + b_{12}m_{12}) (3.32)</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>(y_{21} = a_{21} + b_{21}m_{21}) (3.33)</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>(y_{22} = a_{22} + b_{22}m_{22}) (3.34)</td>
</tr>
</tbody>
</table>
For CD 1, equations (3.31) and (3.32), the aggregate supply over the different farm sizes is

\[ Y_1 = y_{11}N_{11} + y_{12}N_{12} \]
\[ = (a_{11}N_{11} + a_{12}N_{12}) + (b_{11}m_{11}N_{11} + b_{12}m_{12}N_{12}) \]
\[ = a_1 + b_1M_1 \]  \hspace{1cm} (3.35)

where

\[ M_1 = \left( \frac{x_{11}N_{11}}{x_1} \right)m_{11} + \left( \frac{(1-x_{11})N_{12}}{x_1} \right)m_{12} \]  \hspace{1cm} (3.36)

\[ x_{11} = E(\text{area}_{11}) \]
\[ x_1 = E(\text{area}_{11}) + E(\text{area}_{12}) \]  \hspace{1cm} (3.37)

and

\[ b_1 = \frac{b_{11}N_{11} + b_{12}m_{12}N_{12}}{M_1} \]

Then, from (3.37) we can write

\[ b_1M_1 = b_{11}N_{11} + b_{12}m_{12}N_{12} \]  \hspace{1cm} (3.38)

Substituting (3.36) into (3.38) yields

\[ b_1 \left( \frac{x_{11}N_{11}}{x_1} \right)m_{11} + b_1 \left( \frac{(1-x_{11})N_{12}}{x_1} \right)m_{12} = b_{11}N_{11} + b_{12}m_{12}N_{12} \]  \hspace{1cm} (3.39)

From (3.39) the only solution that is valid for any values of \(m_{11}\) and \(m_{12}\) is

\[ b_{11} = b_1 \left( \frac{x_{11}}{x_1} \right) \]
\[ b_{12} = b_1 \left( \frac{1 - x_{11}}{x_1} \right). \]

Hence, the micro coefficients \( b_{11} \) and \( b_{12} \) can be recovered from the CD-level coefficient \( b_1 \) and representative values for \( x_{11} \) and \( x_1 \).

Likewise for CD 2 Equations (3.33) and (3.34), the aggregate supply is

\[ Y_2 = y_{21} N_{21} + y_{22} N_{22}. \]

By following the above methodology the aggregate supply can be derived as

\[ Y_2 = a_2 + b_2 M_2 \quad (3.40) \]

Then, with the same manipulation the micro coefficients can be recovered as follows

\[ b_{21} = b_2 \left( \frac{x_{21}}{x_2} \right) \quad \text{and} \]

\[ b_{22} = b_2 \left( \frac{1 - x_{21}}{x_2} \right). \]

The methodology for aggregation over CDs can be developed as follows, let the CD-level model be represented as follows:

\[
\begin{align*}
\text{CD} & \\
1 & \quad Y_1 = a_1 + b_1 M_1 \quad (3.41) \\
2 & \quad Y_2 = a_2 + b_2 M_2 \quad (3.42)
\end{align*}
\]

And, let the aggregate provincial supply be specified as
\[ Y = Y_1 + Y_2 \]
\[ = \left( a_1 + a_2 \right) + \left( b_1 M_1 + b_2 M_2 \right) \]
\[ = a + bM \]  (3.43)

where
\[ M = \left( \frac{X_1}{X} \right) M_1 + \left( \frac{1 - X_1}{X} \right) M_2 \]  (3.44)
\[ X_1 = E(\text{area in CD} \, 1) \]
\[ X = E(\text{area in both CD's}) \]
and \[ b = \frac{b_1 M_1 + b_2 M_2}{M} \].

From (3.35) we have
\[ bM = b_1 M_1 + b_2 M_2 \]  (3.45)

By substituting (3.44) into (3.45) the following relationship can be obtained.
\[ b\left( \frac{X_1}{X} \right) M_1 + b\left( \frac{1 - X_1}{X} \right) M_2 = b_1 M_1 + b_2 M_2 \]

From this relation \[ b_1 \] and \[ b_2 \] can be recovered as:
\[ b_1 = \left( \frac{X_1}{X} \right) b \text{ and } b_2 = \left( \frac{1 - X_1}{X} \right) b. \]

(v) \textit{Multi-Stage Aggregation with Aggregation Bias}

Let us now consider the recoverability of micro-coefficients from a given aggregate function with two farm types ("small" and "large") and aggregation bias. The Theil approach can be applied to account for aggregation bias.

The micro-level supply functions are:
\begin{align*}
  y_{1j} &= a_1 + b_1 m_{1j} + u_{1j} \quad (3.46) \\
  y_{2j} &= a_2 + b_2 m_{2j} + u_{2j} \quad (3.47)
\end{align*}

where
\begin{align*}
  j &= 1, \ldots, N_1 \text{ for "small" farms} \\
  j &= N_1 + 1, \ldots, N_1 + N_2 \text{ for "large" farms.}
\end{align*}

The aggregate equation can be specified as

\begin{equation}
  Y = a + bM + U \quad (3.48)
\end{equation}

Suppose the following relationships exists:

\begin{align*}
  y_{kj} &= \lambda_k Y \quad (3.49)
\end{align*}

where:
\begin{align*}
  \text{For } k = 1, 2, \ y_{kj} = y_{1j} N_1 + y_{2j} N_2 \quad (3.50)
\end{align*}

\begin{align*}
  m_{kj} &= s_k M \quad (3.51)
\end{align*}

Following Stoker (1994), limited heterogeneity is assumed. That is, the homogeneous production within a given farm type is assumed. By substituting (3.48) and (3.50) into (3.49) the following equation can be derived:

\begin{align*}
  y_{1j} N_1 + y_{2j} N_2 &= \lambda k [a + bM + U] \quad (3.52)
\end{align*}

Substituting (3.46) and (3.47) and (3.51) into (3.52), yields the following aggregate equation in terms of micro and macro variables and coefficients.
\[
\left[ a_1 + b_1 m_{1j} \right] N_1 + \left[ a_2 + b_2 m_{2j} \right] N_2 = \lambda_k \left[ a + \frac{b}{s_k} M_{kj} \right]
\] (3.53)

Following Theil (1954), the revenues of different farms may have somewhat different relationships to aggregate farm revenue. We may express these relationships as follows:

\[
m_{1j} = \alpha_1 + \beta_1 M_{kj} + \epsilon_{1j}
m_{2j} = \alpha_2 + \beta_2 M_{kj} + \epsilon_{2j}
\] (3.54)

The coefficients \( \alpha_1, \alpha_2, \beta_1, \beta_2 \) can be estimated using regression methods.

Substituting (3.54) into aggregate equation (3.53) yields the aggregate equation in terms of the macro variables and micro coefficients:

\[
\left[ a_1 + b_1 \left( \alpha_1 + \beta_1 M_{kj} + \epsilon_{1j} \right) \right] N_1 + \left[ a_2 + b_2 \left( \alpha_2 + \beta_2 M_{kj} + \epsilon_{2j} \right) \right] N_2
\]

\[
= \lambda_k \left[ a + \frac{b}{s_k} M_{kj} \right]
\] (3.55)

From (3.55) the coefficients of the micro system can be derived as follows

(i) intercept:

\[
\left[ a_1 N_1 + a_2 N_2 + b_1 \alpha_1 N_1 + b_2 \alpha_2 N_2 \right] = \lambda_k a
\] (3.56)

(ii) the coefficient on expected revenues:

\[
\left[ b_1 \beta_1 N_1 + b_2 \beta_2 N_2 \right] = \lambda_k b
\] (3.57)
3.2.4 Recoverability in a Two-Moment Supply Model

According to MNL (1994), and based on ex ante rational expectation, \( Y \) is a function of two arguments: the expected revenue and the variance of revenue. This model is attractive for analyzing the effects of NISA-type income stabilization programs because such programs tend to increase expected revenue and reduce the variance. Hence, in this section is described a methodology for recovering individual level supply function coefficients from an aggregate supply function involving these two moments as regressors. This is an extension and generalization of multi-stage aggregation with aggregation bias as discussed in the previous section.

For the purposes of the empirical illustration in chapter 4, the methodology is extended and generalized for \( i=1, 2, 3 \) types of RFs (these representative farms are based in the crop districts highlighted in Table 4.1) where 1 stands for "small", 2 stands for "medium", and 3 stands for "large". The model consists of three acreage equations -- one for each of the three sizes of farms (Equations 3.58 to 3.60). Here, \( y_{1kt} \) is the area (acreage) planted by "small" farms in crop district \( k \) at time \( t \) and is assumed to be a function of the expected revenue from the whole farm operation, \( E(m_{1kt}) \), and the variance of expected revenue, \( \text{var}(m_{1kt}) \). Likewise, \( y_{2kt} \) and \( y_{3kt} \) are the area (acreage) planted by "medium" and "large" farms respectively in region \( k \) and are assumed to be a function of expected revenue, \( E(m_{2kt}) \) and \( E(m_{3kt}) \) and the variance, \( \text{var}(m_{2kt}) \) and \( \text{var}(m_{3kt}) \) respectively.

Let us consider the problem of aggregation over farms and crop districts for estimating coefficients in the following micro equations: The micro and macro acreage supply functions can be specified respectively as:

"Small" \[
y_{1kt} = a_{1k} + b_{1k} \cdot E(m_{1kt}) + c_{1k} \cdot \text{var}(m_{1kt}) + u_{1kt}
\]  
(3.58)

"Medium" \[
y_{2kt} = a_{2k} + b_{2k} \cdot E(m_{2kt}) + c_{2k} \cdot \text{var}(m_{2kt}) + u_{2kt}
\]  
(3.59)

"Large" \[
y_{3kt} = a_{3k} + b_{3k} \cdot E(m_{3kt}) + c_{3k} \cdot \text{var}(m_{3kt}) + u_{3kt}
\]  
(3.60)
where \( k = 1, \ldots, K \) where \( K \) is the number of regions.

The aggregate equation can be specified as

\[
Y_t = a + b E(M_t) + c \text{var}(M_t).
\]  

(3.61)

where \( Y_t \) is the aggregate area (acreage) planted by farms in the province. \( M_t \) is the aggregate expected revenues per acre from operating these farms.

Following Stoker (1994), we assume limited heterogeneity. That is, we assume homogeneous production within a given farm type and given crop district. However, we allow for heterogeneity between farm types and geographic location (crop district).

Suppose the following relationship exists:

\[
Y_{kt} = \lambda_k Y_t
\]

\[
Y_{kt} = y_{1kt} N_{1kt} + y_{2kt} N_{2kt} + y_{3kt} N_{3kt}
\]

(3.62)

where \( Y_{kt} \) is the area planted by all three farm types in region \( k \) at time \( t \) and \( Y_t \) is the total area planted by the province at time \( t \). \( N_{ikt} \) is the number of farms in type \( i = 1, 2, 3 \) in region \( k \) at time \( t \). Equation (3.62) states that crop district \( k \) has \( \lambda_k \) proportion of total crop area of the province.

\[
M_{kt} = s_k M_t
\]

(3.63)

where \( M_{kt} \) is the revenue per acre of all three farm types in region \( k \) at time \( t \) and \( M_t \) is the revenue per acre of the whole province at time \( t \). Equation (3.63) states that revenue per acre is \( s_k \) proportion of revenue per acre for the whole province.
\[
E(M_{kt}) = s_k E(M_t) \\
\text{var}(M_{kt}) = s_k^2 \text{var}(M_t)
\] (3. 64) (3. 65)

By substituting (3. 61) and (3. 63) through (3. 65) into (3. 62), the following equation can be derived.

\[
y_{1kt} N_{1kt} + y_{2kt} N_{2kt} + y_{3kt} N_{3kt} = \lambda_k \left[ a + b E(M_t) + c \text{var}(M_t) \right]
\]

\[
= \lambda_k \left[ a + \left( \frac{b}{s_k} \right) E(M_{kt}) + \left( \frac{c}{s_k^2} \right) \text{var}(M_{kt}) \right]
\] (3. 66)

Ignoring \( u_{1kt}, u_{2kt} \) and \( u_{3kt} \) and substituting (3.58) through (3.60) into (3.66), yields the aggregate equation in terms of micro and macro variables and coefficients:

\[
\begin{align*}
[a_{1k} + b_{1k} E(m_{1kt}) + c_{1k} \text{var}(m_{1kt})] N_{1kt} + \\
[a_{2k} + b_{2k} E(m_{2kt}) + c_{2k} \text{var}(m_{2kt})] N_{2kt} + \\
[a_{3k} + b_{3k} E(m_{3kt}) + c_{3k} \text{var}(m_{3kt})] N_{3kt} = \\
\lambda_k \left[ a + \left( \frac{b}{s_k} \right) E(M_{kt}) + \left( \frac{c}{s_k^2} \right) \text{var}(M_{kt}) \right]
\end{align*}
\] (3. 67)

Following Theil (1954), the revenues of different farms may have somewhat different relationships to aggregate farm revenue. We may express these relationships as follows:

\[
m_{1kt} = \alpha_1 + \beta_1 M_{kt} + \epsilon_{1kt} \\
m_{2kt} = \alpha_2 + \beta_2 M_{kt} + \epsilon_{2kt} \\
m_{3kt} = \alpha_3 + \beta_3 M_{kt} + \epsilon_{3kt}
\] (3. 68)

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The coefficients $\alpha_1, \alpha_2, \alpha_3, \beta_1, \beta_2, \beta_3$ as well as $\text{var } \varepsilon_1, \text{var } \varepsilon_2$, and $\text{var } \varepsilon_3$ can be estimated using regression methods that employ data from $k=1, \ldots, K$ and $t=1, \ldots, T$.

From (3.68) the following relations can be derived:

$$E(m_{1kt}) = \alpha_1 + \beta_1 E(M_{kt})$$
$$E(m_{2kt}) = \alpha_2 + \beta_2 E(M_{kt})$$
$$E(m_{3kt}) = \alpha_3 + \beta_3 E(M_{kt})$$

$$\text{var } (m_{1kt}) = \beta_1^2 \text{var } (M_{kt}) + \text{var } \varepsilon_{1kt}$$
$$\text{var } (m_{2kt}) = \beta_2^2 \text{var } (M_{kt}) + \text{var } \varepsilon_{2kt}$$
$$\text{var } (m_{3kt}) = \beta_3^2 \text{var } (M_{kt}) + \text{var } \varepsilon_{3kt}$$

$$E(m_{1kt}) = \alpha_1 + \beta_1 E(M_{kt})$$
$$E(m_{2kt}) = \alpha_2 + \beta_2 E(M_{kt})$$
$$E(m_{3kt}) = \alpha_3 + \beta_3 E(M_{kt})$$

$$\text{var } (m_{1kt}) = \beta_1^2 \text{var } (M_{kt}) + \text{var } \varepsilon_{1kt}$$
$$\text{var } (m_{2kt}) = \beta_2^2 \text{var } (M_{kt}) + \text{var } \varepsilon_{2kt}$$
$$\text{var } (m_{3kt}) = \beta_3^2 \text{var } (M_{kt}) + \text{var } \varepsilon_{3kt}$$

Substituting these results into aggregate equation (3.67) yields the aggregate equation in terms of macro variables and micro coefficients:

$$\left[ a_1 + b_1 \left( \alpha_1 + \beta_1 E(M_{kt}) \right) + c_1 \left( \beta_1^2 \text{var } (M_{kt}) + \text{var } (\varepsilon_{1kt}) \right) \right] N_{1kt} +$$

$$\left[ a_2 + b_2 \left( \alpha_2 + \beta_2 E(M_{kt}) \right) + c_2 \left( \beta_2^2 \text{var } (M_{kt}) + \text{var } (\varepsilon_{2kt}) \right) \right] N_{2kt} +$$

$$\left[ a_3 + b_3 \left( \alpha_3 + \beta_3 E(M_{kt}) \right) + c_3 \left( \beta_3^2 \text{var } (M_{kt}) + \text{var } (\varepsilon_{3kt}) \right) \right] N_{3kt} =$$

$$\lambda_k \left[ a + \frac{b}{s_k} E(M_{kt}) + \frac{c}{s_k^2} \text{var } (M_{kt}) \right]$$

From (3.70) the coefficients of the micro system can be derived as follows
(i) intercepts:

\[
\begin{bmatrix}
a_{1k} N_{1kr} + a_{2k} N_{2kr} + a_{3k} N_{3kr} + b_{1k} \alpha_1 N_{1kr} + b_{2k} \alpha_2 N_{2kr} + b_{3k} \alpha_3 N_{3kr} + c_{1k} N_{1kr} \text{var}(\varepsilon_{1kr}) + c_{2k} N_{2kr} \text{var}(\varepsilon_{2kr}) + c_{3k} N_{3kr} \text{var}(\varepsilon_{3kr})
\end{bmatrix} = \lambda_k a
\]

(3.71)

with the side conditions \(a_{1k} = \theta_{1k} a_{2k} = \theta_{3k} a_{3k}\). The macrointercept is the sum of the corresponding microcoefficients plus a series of terms involving noncorresponding parameters.

(ii) the coefficient on expected revenues:

\[
\begin{bmatrix} b_{1k} \beta_1 N_{1kr} + b_{2k} \beta_2 N_{2kr} + b_{3k} \beta_3 N_{3kr} \end{bmatrix} = \frac{\lambda_k b}{s_k}
\]

(3.72)

with the side conditions \(b_{1k} = b_{2k} = b_{3k}\). The macregression coefficient \(b_k\) is the arithmetic means of the corresponding microvalues plus a weighted arithmetic sum of noncorresponding microcoefficients \(\beta_i\).

(iii) the coefficient on variance of expected revenues:

\[
\begin{bmatrix} c_{1k} \beta_1^2 N_{1kr} + c_{2k} \beta_2^2 N_{2kr} + c_{3k} \beta_3^2 N_{3kr} \end{bmatrix} = \left(\frac{\lambda_k c}{s_k^2}\right)
\]

(3.73)

with the side conditions \(c_{1k} = c_{2k} = c_{3k}\). The macregression coefficient \(c_k\) is the arithmetic means of the corresponding microvalues plus a weighted arithmetic sum of noncorresponding microcoefficients \(\beta_i\).
For illustrative purposes consider the following numerical example in which all micro coefficients are recovered from the aggregate supply function. Assume the following aggregate supply function has been estimated for the province as a whole:

\[ Y_t = 10000 + 10 E(M_t) - 2 \text{ var } (M_t). \]

In addition, suppose we have estimated:

- \( \lambda_k = 0.10 \) (crop area in region k as a proportion of crop area in whole province).
- \( s_k = 0.15 \) (grain income in region k as a proportion of provincial income from grain).
- \( y_{1kt} = 400 \).
- \( y_{2kt} = 800 \).
- \( y_{3kt} = 1200 \).
- \( E(m_{1kt}) = 100 \).
- \( E(m_{2kt}) = 180 \).
- \( E(m_{3kt}) = 250 \).
- \( \text{var } (m_{1kt}) = 50 \).
- \( \text{var } (m_{2kt}) = 90 \).
- \( \text{var } (m_{3kt}) = 120 \).

\[ (3.74) \]

- \( N_{1kt} = 500 \) (the number of farms in the "small" type farm in region k).
- \( N_{2kt} = 200 \) (the number of farms in the "medium" type farm in region k).
- \( N_{3kt} = 100 \) (the number of farms in the "large" type farm in region k).

Assume that from previous (farm-level) analysis it has been estimated that "small" farms are on average only 70 percent as supply responsive with respect to a change in \( E(M_t) \) as "medium" farms and only 40 percent as supply responsive as "large" farms. Thus, \( b_1 = 0.70b_2 = 0.40b_3 \). Assume also that from previous (farm-level) analysis it has been estimated that "small", "medium" and "large" farms are equally responsive with
respect to a change in $\text{var}(M_t)$. Thus $c_1 = c_2 = c_3$. Furthermore, suppose the estimated equations (3.68) using data from region $k=1, \ldots, K$ and time $t=1, \ldots, T$ are as follows

\[ m_{1kr} = 3 + 0.5M_{kr}, \text{ where } \text{var}(\varepsilon_1) = 80. \]
\[ m_{2kr} = 2 + 0.3M_{kr}, \text{ where } \text{var}(\varepsilon_2) = 120. \]
\[ m_{3kr} = -5 + 0.2M_{kr}, \text{ where } \text{var}(\varepsilon_3) = 160. \]

Substituting these values into (3.72) and (3.73) the micro coefficients $b_1$, $b_2$, and $b_3$ as well as $c_1$, $c_2$, and $c_3$ can be recovered. Thus, from (3.74):

\[ 0.7(0.3b_3) \cdot 0.5 \times 500 + (0.3b_3) \cdot 0.3 \times 200 + b_3 \cdot 0.2 \cdot 100 = \frac{0.10 \times 10}{0.15} \]
\[ (30 + 18 + 20)b_3 = 6.67 \]
\[ b_3 = 0.98 \]
\[ b_1 = 0.069 \]
\[ b_2 = 0.029 \]

By using the above information and applying them to equation (3.73), $c_1$, $c_2$, and $c_3$ can be calculated as

\[ c_1 \beta_1^2 N_{1t} + c_2 \beta_2^2 N_{2t} + c_3 \beta_3^2 N_{3t} = \frac{\lambda_k c}{s_k} \]
\[ c_3 \cdot (0.5)^2 \cdot 500 + c_3 \cdot (0.3)^2 \cdot 200 + c_3 \cdot c_3 \cdot (0.2)^2 \cdot (100) = \frac{-2.0 \cdot 0.10}{(0.15)^2} \]
\[ c_3(125 + 18 + 4) = -8.89 \]
\[ c_3 = -0.0604 \]
\[ c_1 = -0.0604 \]
\[ c_2 = -0.0604 \]
By substituting (3.74), (3.75), and (3.76) into (3.58) through (3.60) the intercepts can be recovered as follows:

\begin{align*}
400 &= a_1 + 0.069(100) + (-0.0604)(50) \\
800 &= a_2 + 0.029(180) + (-0.0604)(90) \\
1200 &= a_3 + 0.98(250) + (-0.0604)(120) \\
a_1 &= 396.12 \\
a_2 &= 800.216 \\
a_3 &= 962.25
\end{align*} 

(3.77)

Thus, the micro-level supply equations consistent with the aggregate supply equation are:

\begin{align*}
\text{"Small"} & \quad y_{1kt} = 396.12 + 0.069 E(m_{1kt}) - 0.0604 \text{var}(m_{1kt}) + u_{1kt} \\
\text{"Medium"} & \quad y_{2kt} = 800.22 + 0.029 E(m_{2kt}) - 0.0604 \text{var}(m_{2kt}) + u_{2kt} \\
\text{"Large"} & \quad y_{3kt} = 962.25 + 0.98 E(m_{3kt}) - 0.0604 \text{var}(m_{3kt}) + u_{3kt}
\end{align*} 

(3.78) (3.79) (3.80)

It is possible to develop estimates of the standard errors of these coefficients which may then be used as a basis for hypothesis testing and confidence interval estimation. The micro-level estimated coefficients are functions of other random variables (parameter estimates) whose distribution have already been estimated. The methodology for obtaining estimates of the variances of these micro-level coefficients is described in Kmenta (1986, p. 486) and Fulton and Karp (1989).

3.3 Simulation Methodology

The first component of the methodology for analyzing the aggregate effects of NISA-type income stabilization programs is the estimation of supply functions for representative farms which are consistent with a directly-estimated aggregate supply
function. This component was completed in the above section. The second component of the methodology is the micro-level simulation. Once the individual-level supply functions are estimated then the stabilization policy rules are imposed on the representative farm simulation model and the micro-level (representative farm) effects are simulated. A description of this simulation methodology is provided immediately below.

A NISA-type stabilization program involves an individual stabilization account to which the farmer makes annual deposits and, if triggered, can make withdrawals.

The micro-simulation methodology dynamic is stochastic simulation of the stabilization account for representative farms over a prospective multi-year period. Dynamic stochastic simulation is the most appropriate approach to use because the policy is dynamic (withdrawals are based on a moving average of past gross margins) and operates on the basis of fluctuations in random variables (price and yields). The purposes of the present study is to build upon the methodology to generate estimates of the aggregate level effects of NISA for Saskatchewan as a whole.

The following section is in two parts. Section 3.3.1 summarizes the basic dynamic stochastic simulation methodology as used by Spriggs and Taylor and which is used as the basis for the simulation methodology in this thesis. Section 3.3.2 describes the modification of the Spriggs-Taylor methodology required to incorporate supply response.

3.3.1 Spriggs-Taylor Micro Simulation Methodology

This methodology involves dynamic stochastic simulation of the NISA-type stabilization account for representative farms over a prospective 10-year period (Spriggs-Taylor, 1994). The authors agree that dynamic stochastic simulation is the most appropriate approach to use because the policy is dynamic (withdrawals are based on a moving average of past gross margins) and it operates on the basis of fluctuations in random variables (price and yields).
An important model specification problem is that of prices being endogenous at the macro level but exogenous at the micro level. In this study, such a problem is sidestepped because it is reasonable to assume that prices are exogenous at both levels in Canada. Revenues are generated using randomly chosen prices and yields from specified multivariate probability distributions. In any given year, crop yields are assumed to be correlated with each other and prices are assumed to be correlated with each other. However, crop yields are not assumed to be correlated with prices. The rationale for allowing cross-commodity correlation of prices is that these prices are basically determined in international markets which are related. The rationale for allowing cross-commodity correlation of yields is that weather variables may affect all crop yields in a particular crop district. The rationale for not allowing correlation between prices and yields is that Saskatchewan production variability is not sufficiently large to influence world prices and Saskatchewan yields are thought to be primarily affected by weather and only marginally affected by prices. Thus, prices were assumed to be exogenous at both micro- and macro-models.

The probability distribution of prices, was assumed to be log-normal. For prices, the log-normal is preferred to the normal since it is a smooth distribution with a lower bound of zero. With respect to the multivariate probability distribution of yields, this was assumed to be truncated-normal (truncated at zero). Unlike the case of price, where a value of zero is extremely unlikely, a zero yield is quite possible. Note also that the yield distribution is based on that of an individual farm rather than an area average. Clearly, the variation of yield of an individual farm will be greater than that of the area average.

A large number (200) of random price and yields are generated for the multi-year prospective simulation period (ten years in their study). Each representative farm has a unique replicate spreadsheet (developed in EXCEL 5.0 software), containing information based on income tax data. These data are averages of information supplied directly by farmers on their income tax forms. Expenses are entered as deterministic (non-stochastic)
items over the same time period. Formulas are placed in appropriate cells in the spreadsheet to calculate the desired output variables (e.g., gross margin, contributions, withdrawals, account balances, adjusted gross margin and government cost)\(^1\).

A macro spreadsheet, (also using EXCEL), takes each time path of prices and yields, together with the other financial data, applies the policy rules of the stabilization program and generates the desired output variables which are subsequently saved on separate spreadsheets. See Figure 3.2 which is a flowchart of the Spriggs-Taylor micro simulation model.

Spriggs and Taylor (1994) used three criteria to assess various policy alternatives. These were: (1) stabilization potential; (2) level of income support; and (3) government cost. They used the following criterion to measure the stability of gross margin for a given time path, \(i\).

\[
S_i = \left[ \frac{T}{T-1} \sum_{t=2}^{T} \left( m_{tt} - m_{i(t-1)} \right)^2 \right]^{1/2}
\]

where \(m\) = gross margin, including withdrawals, net of contributions;

\(t\) = time in years;

\(i = i^{th}\) simulation.

---

\(^1\) Adjusted gross margin is defined as gross margin plus withdrawals minus contributions.
Start macro for first replicate (i.e., i = 1)

Read replicate i on stochastic price and yield variables from input files

Do calculations in representative farm spreadsheet

Copy gross margins, adjusted gross margins, contributions, account balance, govt. costs to output files

Is rep = 200?

No

Yes

Compute summary statistics (e.g., means and standard deviations, and probability of account balance being zero)


Figure 3.2. Flowchart of the Stochastic Simulation Model.
They calculated $S^N_i$ for NISA which represents the stability of adjusted gross margin (i.e., gross margin plus withdrawals minus contributions). $S_i$ and $S^N_i$ for no policy and NISA, respectively can be calculated for each simulation and averaged over the 200 replicates to obtain $\bar{S}$ and $\bar{S}^N$. An S-ratio, $\frac{S^N}{\bar{S}}$, can then be computed. This ratio gives a measure of the stabilizing effects of NISA. Spriggs and Taylor computed the S ratio assuming no supply response. In the present study the S-ratio will be computed with supply response.

The level of income support can be measured by adjusted gross margin (AGM). The AGM can be compared to gross margin under no policy which is averaged over 10 years and over 200 replicates.

The government contributes to NISA through government contribution to the account and an interest bonus for the producer portion of the account; these two combined measure the level of government support. This is a measure of total subsidy and support. The level of income support is only a partial measure since some of government support ends up as wealth accumulation in the prospective stabilization account.

3.3.2 The Micro Simulation Model with Supply Response

McLennan (1995) modified the Spriggs-Taylor micro simulation model to incorporate a supply response function. The Spriggs-Taylor model was based on a constant acreage over the simulation period. However, McLennan adapted this model to incorporate supply response at the individual representative farm level. The procedure was as follows:

(1) Individual-level supply functions, estimated in the present study (Equations 3.58 through 3.60) for three farm types and for eight regions, were introduced into each representative farm spreadsheet.
(2) Crop area is to be estimated on the basis of the supply functions in (1) using an iterative process. Starting values are selected for expected revenue, $E_0(m_{ijkt})$, and variance of revenue, $\text{var}_0(m_{ijkt})$, and these together determine an initial value for crop area for each of the 24 representative farms and for each year of the perspective simulation period.

(3) The Spriggs-Taylor micro simulation methodology is applied to the initial crop area and the mean and variance of the 200 replicates of adjusted gross margin, $E_1(m_{ijkt})$ and $\text{var}_1(m_{ijkt})$, are calculated.

(4) Second-round estimates of crop area are now estimated based on $E_1(m_{ijkt})$ and $\text{var}_1(m_{ijkt})$ and the Spriggs-Taylor micro simulation methodology is applied again.

(5) This iterative procedure continues until the change in crop area from one iteration to the next is less than 5 percent.

(6) When convergence is achieved, the crop area for each year of the prospective simulation period is deemed to be consistent with ex ante rational expectations.

(7) Finally, these optimal crop areas are used in conjunction with the Spriggs-Taylor methodology to generate final iteration values for adjusted gross margin, gross margin and government cost. These values are then subjected to the aggregation methodology to obtain the aggregate effects of policy on income, government cost and crop area.

This iterative procedure is summarized in Figure 3.3. The aggregation methodology will be discussed in the following section.

3.4 Aggregation Methodology

The first two components of the methodology proposed in this thesis have been described in the previous two sections. They are: (a) recovering two-moment individual-level supply functions from an aggregate supply function; and (b) micro simulation of
NISA-type stabilization programs allowing for supply response. The third component of the methodology is aggregating the micro-level effects. This is the subject of the current section.

Once the micro simulation analysis has been completed, all the replicates on the desired output variables (e.g., gross margin, adjusted gross margin and government cost) on each of the 3 representative farms in each of k regions for each year of the prospective simulation period will be available: \( m_{ijkl}, \ i = 1,\ldots,I; \ j = 1,\ldots,J; \ k = 1,\ldots,K; \ t = 1,\ldots,T. \)

The next step is to estimate the aggregate value for the desired output variable for each region over the 3 sizes of farms: \( M_{ikt} \), where

\[
M_{ikt} = \sum_{j=1}^{J} N_{jk} m_{ijkl}
\]  

(3.81)

and, where \( N_{jk} \) is the number of farms in the "small", "medium" and "large" farm categories in region k.

Total crop area on farms of the type represented in each region \( (Y_k) \) is calculated using the expression:

\[
Y_k = \sum_{j=1}^{J} N_{jk} y_{jk}
\]  

(3.82)

and, where \( y_{jk} \) is the crop area estimated on each representative farm.

However, there is another variable of interest, but it operates only at the individual farm level. This is the S-ratio as discussed in Spriggs and Taylor (1994). The S-ratio can be interpreted as the year-year variability of income under a policy option, as a percentage of year-to-year variability under no policy. The S-ratio is a measure of the effectiveness of the alternative policy options in stabilizing an individual's adjusted gross
margin over time. In the present study, the S-ratio is used to measure the stability of gross margin for a given time path.
Figure 3.3 Flowchart of Simulation Model
3.5 Summary

According to the literature review in chapter 2, the type of income support policy that appears to be evolving in Canada is the whole farm NISA-type income stabilization program. The rules for this type of program operates at the individual producer level rather than the commodity level. If we wish to analyze the aggregate effects of such a program, the recent literature (e.g., Stoker, 1993) suggests the most appropriate methodology would involve the estimation of aggregate response functions and, assuming limited heterogeneity, the derivation of individual-level response functions that are consistent with the aggregate response function. Our review of literature does not reveal an appropriate methodology in the agricultural economics literature for doing this. Hence the objective of chapter 3 has been to develop such a methodology. This methodology involves three components: (a) the recoverability of two-moment individual-level supply functions from an aggregate supply function; (b) micro simulation model for a NISA-type program which allows for supply response; and (c) a methodology to aggregate the micro-level effects.

In the next chapter the basic NISA-type program will be analyzed to illustrate the multi-stage aggregation methodology developed in chapter 3.
CHAPTER 4

AN EMPIRICAL ILLUSTRATION OF
THE AGGREGATION METHODOLOGY

4.1 Introduction

The purpose of this chapter is to apply the aggregation-consistent individual methodology (the selected multi-stage aggregation model), that was developed in chapter 3. In this illustration analysis, supply functions are derived for 24 representative grains and oilseeds (G&O) farms in Saskatchewan from an estimated aggregate supply function. The aggregate effects of a NISA-type stabilization program are estimated and compared with the aggregate effects estimated in a pervious study which is not take the supply response into account. This earlier study was by Spriggs, Taylor, Hosseini, McLennan, and Niekamp (1995). Much of the data and basic modeling framework is taken from their study to facilitate the empirical comparisons. Various policy alternatives are assessed at the aggregate level by examining: (1) adjusted gross margin; and (2) government cost.

This chapter is in three sections. Section 4.2 presents the estimation of individual representative supply functions that are consistent with a previously estimated aggregate supply function. In section 4.3 is presented the simulation analysis and results of the policy effects at the individual representative farm level. In section 4.4 is presented the aggregation analysis and results.

4.2 Estimation of the Representative Farm Supply Functions

The purpose of this section is to apply the aggregation methodology described in chapter 3 to estimate a set of supply functions for representative G&O farms in Saskatchewan. In all, 24 representative farms are estimated. They are characterized as farms with gross farm receipts of at least $10,000 and which earn at least 75 percent of
their farm revenue from grains and oilseeds. These 24 RFs include three farm types (small, medium, and large) in each of eight regions of the province. The small farm is defined as one earning $10,000 to $50,000 in gross farm revenue, a medium farm is defined as one earning $50,000 to $100,000 and a large farm is defined as one earning $100,000 to $250,000. The eight regions comprise all 20 crop districts as indicated in Table 4.1.

Table 4.1. Number of Grains and Oilseeds Farms, Eight Regions of Saskatchewan, 1991.

<table>
<thead>
<tr>
<th>Region</th>
<th>Soil Zone</th>
<th>Crop Districts*</th>
<th>$N_{1k}$</th>
<th>$N_{2k}$</th>
<th>$N_{3k}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Brown</td>
<td>3AN.3AS.3BN.3BS,4A.AB</td>
<td>2120</td>
<td>2405</td>
<td>780</td>
</tr>
<tr>
<td>2</td>
<td>Brown</td>
<td>7A</td>
<td>575</td>
<td>595</td>
<td>240</td>
</tr>
<tr>
<td>3</td>
<td>Dark Brown</td>
<td>1A.2A.2B</td>
<td>1945</td>
<td>1755</td>
<td>980</td>
</tr>
<tr>
<td>4</td>
<td>Dark Brown</td>
<td>6A.6B</td>
<td>1665</td>
<td>1475</td>
<td>775</td>
</tr>
<tr>
<td>5</td>
<td>Dark Brown</td>
<td>7B</td>
<td>445</td>
<td>525</td>
<td>260</td>
</tr>
<tr>
<td>6</td>
<td>Black</td>
<td>1B.5A.5B</td>
<td>2160</td>
<td>2265</td>
<td>1170</td>
</tr>
<tr>
<td>7</td>
<td>Black</td>
<td>8A.8B</td>
<td>1115</td>
<td>1255</td>
<td>840</td>
</tr>
<tr>
<td>8</td>
<td>Black</td>
<td>9A.9B</td>
<td>1040</td>
<td>1090</td>
<td>915</td>
</tr>
</tbody>
</table>

*The representative farm for a given region is located in the highlighted crop districts.


According to MNL (1994) the supply function $y_{ik}$ is based on ex ante rational expectations. As such, it is a function of two arguments: the expected per-acre revenue and the variance of per-acre revenue. The selected model for analysis adopts the MNL specification of the supply function along with an extension and generalization of multi-stage aggregation with aggregation bias as discussed in Chapter 3. This model is described and specified for three types of RFs ($i=1, 2, 3$) where 1 stands for "small", 2 stands for "medium", and 3 stands for "large" and $k=1, \ldots, 8$ regions. The model consists of three acreage equations -- one for each of "small", "medium" and "large" farms. Here, $y_{ik}$ is
the crop area (acreage) planted by "small" farms in region $k$ and is assumed to be a function of the expected revenue per-acre from the whole-farm operation, $E(m_{1k})$, and the revenue variance, $\text{var}(m_{1k})$. Likewise, $y_{2k}$ and $y_{3k}$, are the crop areas (acreages) planted by "medium" and "large" farms respectively in region $k$ and are assumed to be a function of expected per-acre revenue, $E(m_{2k})$ and $E(m_{3k})$ and the revenue variance, $\text{var}(m_{2k})$ and $\text{var}(m_{3k})$ respectively.

The purpose of sections 4.2.1 and 4.2.2 below is to recover estimates of the coefficients of the farm-level (micro) supply functions from an already estimated aggregate-level (macro) supply function. This is accomplished in two steps. They are: (1) derive a Saskatchewan aggregate acreage supply function from the MNL's aggregate acreage supply function for western Canada; and (2) recover coefficients for the individual supply functions for the 24 representative farms that are consistent with the coefficients of the Saskatchewan aggregate acreage supply function obtained in (1) above.

These steps are discussed in the sections 4.2.1 and 4.2.2 respectively.

4.2.1 Aggregate Supply Function for Saskatchewan (Macro-Level)

MNL (1994) estimated a log-linear structural acreage supply model for Western Canada. They assumed that farmers based acreage allocation decisions on the ex ante rational expectations and variance of per-acre revenues. They found that the short-run elasticity of acreage supply with respect to expected per acre revenue, $\varepsilon_{m}$, was approximately 0.28 and the short-run elasticity of acreage supply with respect to revenue variance, $\varepsilon_{\text{var}}$, was approximately -0.08. For illustration purposes these elasticities were assumed to hold for Saskatchewan for which the aggregate supply function may be represented linearly as

$$Y = a + b E(M) + c \text{var}(M)$$
The coefficients can be derived as follows

\[
\begin{align*}
    b &= \frac{\partial Y}{\partial E(M)} = \varepsilon_m \frac{Y}{E(M)} \tag{4.1} \\
    c &= \frac{\partial Y}{\partial \text{var}(M)} = \varepsilon_{\text{var}} \frac{Y}{\text{var}(M)} \tag{4.2} \\
    a &= Y - bE(M) - c \text{ var}(M) \tag{4.3}
\end{align*}
\]

where:

\(Y = 23.4\) (millions of acres planted in Saskatchewan to the four major grain crops: wheat, barley, canola, and durum as G&O sector by Spriggs, Taylor, Hosseini, McLennan, and Niekamp (STHMN) (1995));

\(E(M) = \$35\) (expected per-acre revenue from operating G&O sector in Saskatchewan);

\(\text{var}(M) = \$532\) (revenue variance per-acre from operating grain and oilseeds farms in Saskatchewan; and where \(E(M)\) and \(\text{var}(M)\), were generated through a dynamic stochastic simulation model by STHMN (1995)).

Using Equations (4.1), (4.2) and (4.3); the above estimates of \(Y\), \(E(M)\), and \(\text{var}(M)\) from STHMN; \(\varepsilon_m\) and \(\varepsilon_{\text{var}}\) from MNL, the aggregate coefficients, \(b\), \(c\), and \(a\) for the G&O sector of Saskatchewan are estimated as

\[
\begin{align*}
    b &= 187.809 \\
    c &= -3.519 \\
    a &= 18.726.360
\end{align*}
\]

Thus, the estimated aggregate supply function for the G&O sector for Saskatchewan is

\[
Y = 18.726.360 + 187.809 E(M) - 3.519 \text{ var}(M). \tag{4.4}
\]
4.2.2 Individual Supply Functions (Micro-Level)

The individual supply functions (3.58) through (3.60) are specified as linear in this illustration analysis. Following Stoker (1993), limited heterogeneity was assumed. That is, within a given farm type and given region, a homogeneous production is assumed. However, between farm types and geographic location (region) limited heterogeneity is allowed.

To recover estimated coefficients of the individual supply functions, the steps required are:

(i) estimate the regional crop area as a proportion of the total crop area of the province, \( \lambda_k \);

(ii) estimate the regional revenue per-acre as a proportion of the province revenue per-acre, \( s_k \);

(iii) estimate the Theil coefficients, \( \alpha_i \) and \( \beta_i \), indicating the degree of aggregation bias; and

(iv) estimate the consistent individual intercepts and coefficients, which in turn involves:

1. Estimating the coefficients on expected per-acre revenue, \( b_{ik} \);
2. Estimation the coefficients on revenue variance, \( c_{ik} \);
3. Estimating the intercepts of individual supply functions, \( a_{ik} \).

These steps are discussed in the following three sub-sections.

(i) Estimating the Regional Crop Area as a Proportion of the Total Crop Area of the Province, \( \lambda_k \)

Crop area of G&O farms in each region \((k = 1, \ldots, 8)\) is estimated from representative farm data as \( Y_k \), where:

\[
Y_k = y_{1k} * N_{1k} + y_{2k} * N_{2k} + y_{3k} * N_{3k}
\]  

(4.5)
and, where $y_{1k}$, $y_{2k}$, $y_{3k}$ are the crop areas on each RF. These are presented in Table 4.2.

Table 4.2. Crop Area on Representative G&O Farms, Eight Regions of Saskatchewan. 1991.

<table>
<thead>
<tr>
<th>Region</th>
<th>Soil Zone</th>
<th>$y_{1k}$</th>
<th>$y_{2k}$</th>
<th>$y_{3k}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Brown</td>
<td>522</td>
<td>648</td>
<td>1232</td>
</tr>
<tr>
<td>2</td>
<td>Brown</td>
<td>405</td>
<td>520</td>
<td>1040</td>
</tr>
<tr>
<td>3</td>
<td>Dark Brown</td>
<td>371</td>
<td>675</td>
<td>1331</td>
</tr>
<tr>
<td>4</td>
<td>Dark Brown</td>
<td>376</td>
<td>692</td>
<td>1350</td>
</tr>
<tr>
<td>5</td>
<td>Dark Brown</td>
<td>311</td>
<td>569</td>
<td>1102</td>
</tr>
<tr>
<td>6</td>
<td>Black</td>
<td>384</td>
<td>591</td>
<td>994</td>
</tr>
<tr>
<td>7</td>
<td>Black</td>
<td>403</td>
<td>805</td>
<td>1328</td>
</tr>
<tr>
<td>8</td>
<td>Black</td>
<td>457</td>
<td>623</td>
<td>1178</td>
</tr>
</tbody>
</table>


$Y_k$ is the crop area planted by all three farm types in region k, $N_{ik}$ is the number of farms where $i = 1, 2, 3$ and $k = 1, ..., 8$. The relationship between total crop area planted at the region level and the province level are assumed as in Equation (3.51). By using Table 4.1 for the number of farms in each farm type, Table 4.2 for crop area on each representative farm, and Equations (4.5) and (3.51), the regional crop area as a proportion of the province, $\lambda_k$, is estimated for 8 regions. These are provided in Table 4.3.
Table 4.3. $\lambda_k$-Ratios on Eight Regions of Saskatchewan, 1991.

<table>
<thead>
<tr>
<th>Region</th>
<th>$y_{1k} \cdot N_{1k}$</th>
<th>$y_{2k} \cdot N_{2k}$</th>
<th>$y_{3k} \cdot N_{3k}$</th>
<th>$\sum_{i=1}^{3} y_{ik} \cdot N_{ik}$</th>
<th>$\lambda_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,170,240</td>
<td>1,558,440</td>
<td>960,960</td>
<td>3,689,640</td>
<td>0.19</td>
</tr>
<tr>
<td>2</td>
<td>232,875</td>
<td>309,400</td>
<td>249,600</td>
<td>791,875</td>
<td>0.04</td>
</tr>
<tr>
<td>3</td>
<td>721,595</td>
<td>1,184,625</td>
<td>1,304,380</td>
<td>3,210,600</td>
<td>0.17</td>
</tr>
<tr>
<td>4</td>
<td>626,040</td>
<td>1,020,700</td>
<td>1,046,250</td>
<td>2,692,990</td>
<td>0.14</td>
</tr>
<tr>
<td>5</td>
<td>138,395</td>
<td>298,725</td>
<td>286,520</td>
<td>723,640</td>
<td>0.04</td>
</tr>
<tr>
<td>6</td>
<td>829,440</td>
<td>1,338,615</td>
<td>1,162,980</td>
<td>3,331,035</td>
<td>0.17</td>
</tr>
<tr>
<td>7</td>
<td>449,345</td>
<td>1,010,275</td>
<td>1,115,520</td>
<td>2,575,140</td>
<td>0.13</td>
</tr>
<tr>
<td>8</td>
<td>475,280</td>
<td>679,070</td>
<td>1,077,870</td>
<td>2,232,220</td>
<td>0.12</td>
</tr>
<tr>
<td>Sum</td>
<td>19,247,140</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: Calculated Estimates.

(ii) Estimating the Regional Revenue Per-Acre as a Proportion of the Provincial Revenue Per Acre, $s_k$

At this step, the relationship between revenue per acre at the regional level and the provincial level is estimated. This relationship is assumed to be as follows:

$$M_k = s_k M$$  \hspace{1cm} (4.6)

where:

$$M_k = \frac{y_{1k} \cdot N_{1k} \cdot m_{1k} + y_{2k} \cdot N_{2k} \cdot m_{2k} + y_{3k} \cdot N_{3k} \cdot m_{3k}}{y_{1k} \cdot N_{1k} + y_{2k} \cdot N_{2k} + y_{3k} \cdot N_{3k}}$$  \hspace{1cm} (4.7)

$$M = \frac{\sum_{i=1}^{3} \sum_{k=1}^{8} y_{ik} \cdot N_{ik} \cdot M_k}{\sum_{i=1}^{3} \sum_{k=1}^{8} y_{ik} \cdot N_{ik}}$$  \hspace{1cm} (4.8)

where $M_k$ is the weighted sum of revenues per-acre on all three farm types in region $k$ and $M$ is the revenue per-acre (weighted average of revenues per-acre of regions) of the
whole province. In Table 4.4, are presented the revenues per-acre estimated for the different-sized representative farms in each region (STHMN, 1995). These representative farms are based in the crop districts highlighted in Table 4.1.

### Table 4.4. Average Revenue on Representative G&O Farms on a Per Acre Basis ($/acre)

<table>
<thead>
<tr>
<th>Region</th>
<th>$m_{1k}$</th>
<th>$m_{2k}$</th>
<th>$m_{3k}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27.48</td>
<td>34.61</td>
<td>44.44</td>
</tr>
<tr>
<td>2</td>
<td>9.02</td>
<td>28.27</td>
<td>27.07</td>
</tr>
<tr>
<td>3</td>
<td>16.43</td>
<td>23.36</td>
<td>24.94</td>
</tr>
<tr>
<td>4</td>
<td>34.11</td>
<td>33.64</td>
<td>68.40</td>
</tr>
<tr>
<td>5</td>
<td>38.88</td>
<td>49.10</td>
<td>49.84</td>
</tr>
<tr>
<td>6</td>
<td>29.82</td>
<td>39.85</td>
<td>41.43</td>
</tr>
<tr>
<td>7</td>
<td>26.82</td>
<td>39.22</td>
<td>42.78</td>
</tr>
<tr>
<td>8</td>
<td>22.46</td>
<td>27.06</td>
<td>39.03</td>
</tr>
</tbody>
</table>

Source: Simulation Model (STHMN, 1995).

Using $y_{1k} N_{1k}, y_{2k} N_{2k}$, and $y_{3k} N_{3k}$ from Table 4.3; $m_{1k}, m_{2k},$ and $m_{3k}$ from Table 4.4 for each region; and Equations (4.6) and (4.8), $M_k$ and $M$ are calculated. By substituting these values into Equation (4.5), $S_k$ is estimated for 8 regions. The results are presented in Table 4.5.
Table 4.5. $S_k$-Ratios of Grains and Oilseeds Farms, by Region, Saskatchewan.

<table>
<thead>
<tr>
<th>Region</th>
<th>$\sum_{i=1}^{3} y_{ik} N_{ik}$</th>
<th>$M_k$</th>
<th>$S_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3,689,640</td>
<td>34.91</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>791,875</td>
<td>22.23</td>
<td>0.63</td>
</tr>
<tr>
<td>3</td>
<td>3,210,600</td>
<td>22.44</td>
<td>0.64</td>
</tr>
<tr>
<td>4</td>
<td>2,692,990</td>
<td>47.25</td>
<td>1.30</td>
</tr>
<tr>
<td>5</td>
<td>723,640</td>
<td>47.44</td>
<td>1.35</td>
</tr>
<tr>
<td>6</td>
<td>3,331,035</td>
<td>37.90</td>
<td>1.08</td>
</tr>
<tr>
<td>7</td>
<td>2,575,140</td>
<td>38.60</td>
<td>1.10</td>
</tr>
<tr>
<td>8</td>
<td>2,232,220</td>
<td>31.86</td>
<td>0.91</td>
</tr>
<tr>
<td>Sum</td>
<td>19,247,140</td>
<td>35.17</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Source: Calculated Estimates.

(iii) Estimating the Theil Coefficients, $\alpha_i$ and $\beta_i$, for Aggregation Bias

The next step is to estimate the relationships between the farm-level revenue per acre in each region and the revenue per acre of the region as a whole. Following Theil (1954), the revenues of different representative farms may be expected to have somewhat different relationships to aggregate farm revenue per acre. These individual time path differences were expressed in Equations (3. 68). In the present study the same coefficients across regions is assumed. The revenue per acre of different-sized farms in each crop district were regressed on the revenue per acre of that crop district. These relationships are estimated jointly as a system of seemingly unrelated regression equations (SUR) from the NFS and taxfiler data for 1991 to 1993. This includes 20 crop districts within 8 regions. There are 60 observations as a cross sectional time series data. The error terms were assumed to be serial uncorrelated. These estimated equations are as follows:
\[ m_{1kr} = -17.198 + 1.44M_{kr} + \varepsilon_{1kr} \]  
\[ (-7.80) \quad (13.34) \]
\[ m_{2kr} = 9.136 + 0.8M_{kr} + \varepsilon_{2kr} \]  
\[ (3.37) \quad (7.38) \]
\[ m_{3kr} = 8.062 + 0.93M_{kr} + \varepsilon_{3kr} \]  
\[ (4.43) \quad (8.10) \]  

where:

t-statistics are in parentheses beneath coefficients.

To jointly test the validity of equation system (4.9), a Wald test was conducted under the null hypothesis that the sum of all slope coefficients is equal to one and the sum of the constant terms is equal to zero. Under the null hypothesis, the Wald statistic follows a chi square distribution with 2 degrees of freedom. The resulting Wald test statistic of 107.70 was significant at the one percent significance, indicating that the null hypothesis should be rejected.

The coefficients \( \alpha_1, \alpha_2, \alpha_3, \beta_1, \beta_2, \beta_3 \) as well as \( \text{var}(\varepsilon_1), \text{var}(\varepsilon_2), \text{and var}(\varepsilon_3) \) are estimated and presented in Equations (4.9). Also, \( \text{var}(\varepsilon_1), \text{var}(\varepsilon_2), \text{and var}(\varepsilon_3) \) are estimated and presented in Table 4.6.

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Type</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Small</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>Large</td>
</tr>
</tbody>
</table>

Source: Estimates.
(iv) Estimating Consistent Coefficients for Individual-Level Supply Functions

To estimate the individual supply functions [Equations (3.47) through (3.49)], the individual coefficients that were derived in Chapter 3 as Equations (3.60) through (3.62) are estimated. There are three types of coefficients: (1) the coefficients on expected revenues; (2) the coefficients on revenue variances; and (3) the intercepts. They are estimated to be consistent with aggregate supply function coefficients as follows.

(i) Coefficients on Expected Revenues:

From Equation (3.59) the coefficients on expected per-acre revenue are derived as

\[
\left[ b_k \beta_{1k} N_{1k} + b_k \beta_{2k} N_{2k} + b_k \beta_{3k} N_{3k} \right] = \frac{\lambda_k b_k}{s_k} \quad (k = 1, \ldots, 8) \quad (4.10)
\]

Assume that from the farm-level analysis it has been estimated that "small", "medium", and "large" farms are equally responsive with respect to a change in \( E(m_{ik}) \).

Thus, the coefficients on expected per-acre revenue are assumed to be the same across farm types, \( b_k = b_{2k} = b_{3k} \). Using this assumption, Table 4.1 for \( N_{ik} \), Equation (4.4) for the aggregate coefficient \( b \), Table 4.3 for \( \lambda_k \), Table 4.5 for \( s_k \), and Table 4.6 and Equation (4.9) for \( \beta_1 \), \( \beta_2 \), and \( \beta_3 \), the micro coefficients on expected per-acre revenue for three types of farms ("small", "medium", and "large") and 8 regions may be recovered and estimated. The weighted sum of these coefficients are consistent with the aggregate coefficient, \( b \). With respect to these individuals and aggregate coefficients, a consistency check is performed by comparing the weighted sum of individuals coefficients with the estimated aggregate coefficient. The results are presented in Table 4.7. As may be seen, the estimated aggregate coefficient, \( b \), is consistent with the weighted sum of individuals coefficients. This value is equal to 187808.9.
Table 4.7. Estimated Consistent Coefficients on Expected Per-Acre Revenue, Eight Regions of Saskatchewan.

<table>
<thead>
<tr>
<th>Region</th>
<th>$b_{1k}$</th>
<th>$b_{2k}$</th>
<th>$b_{3k}$</th>
<th>$\sum_{i=1}^{3} b_{ik} \beta_{i} N_{ik}$</th>
<th>$s_{k} * \sum_{i=1}^{3} b_{ik} \beta_{i} N_{ik}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.36</td>
<td>6.36</td>
<td>6.36</td>
<td>36,267</td>
<td>36,003</td>
</tr>
<tr>
<td>2</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>12,223</td>
<td>7.727</td>
</tr>
<tr>
<td>3</td>
<td>9.59</td>
<td>9.59</td>
<td>9.59</td>
<td>49,084</td>
<td>31,328</td>
</tr>
<tr>
<td>4</td>
<td>4.55</td>
<td>4.55</td>
<td>4.55</td>
<td>19,555</td>
<td>26,278</td>
</tr>
<tr>
<td>5</td>
<td>4.02</td>
<td>4.02</td>
<td>4.02</td>
<td>5,234</td>
<td>7,061</td>
</tr>
<tr>
<td>6</td>
<td>5.02</td>
<td>5.02</td>
<td>5.02</td>
<td>30,154</td>
<td>32,503</td>
</tr>
<tr>
<td>7</td>
<td>6.75</td>
<td>6.75</td>
<td>6.75</td>
<td>22,892</td>
<td>25,128</td>
</tr>
<tr>
<td>8</td>
<td>7.46</td>
<td>7.46</td>
<td>7.46</td>
<td>24,040</td>
<td>21,781</td>
</tr>
</tbody>
</table>

Consistency Check 187.809

Source: Calculated Estimates.

(2) Coefficients on Revenue Variance:

From Equation (3.59) the individual-level coefficients on revenue variances are derived as

$$\left[ c_{1k} \beta_{1}^{2} N_{1k} + c_{2k} \beta_{2}^{2} N_{2k} + c_{3k} \beta_{3}^{2} N_{3k} \right] = \left( \frac{\lambda_{k} c}{s_{k}^{2}} \right)$$

(4.11)

Here also, the equality of supply responsiveness of farm types with respect to a change in $\text{var} (M_{t})$ from farm-level analysis is assumed. Thus, $c_{1k} = c_{2k} = c_{3k}$. Using this assumption, Equation (3.61), Table 4.6 for $\beta_{1}^{2}$, $\beta_{2}^{2}$, and $\beta_{3}^{2}$, Table 4.1 for $N_{ik}$, Equation (4.4) for aggregate coefficient $c$, and Tables 4.3 and 4.5 for $\lambda_{k}$ and $s_{k}^{2}$ respectively the micro coefficients on revenue variance for three farm types and 8 regions may be recovered and estimated. With respect to these individuals and aggregate coefficients a consistency check is performed by comparing the weighted sum of

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individuals coefficients with estimated aggregate coefficient, \( c \). The results are presented in Table 4.8. As may be seen, the estimated aggregate coefficient, \( c \), is consistent with the weighted sum of individuals coefficients. This value is equal to -3518.9.

**Table 4.8. Estimated Consistent Coefficients on Revenue Per Acre Variance. Eight Regions of Saskatchewan.**

<table>
<thead>
<tr>
<th>Region</th>
<th>( c_{1k} )</th>
<th>( c_{2k} )</th>
<th>( c_{3k} )</th>
<th>( \sum_{i=1}^{3} c_{ik} \beta_i^2 N_{ik} )</th>
<th>( s_k^2 \sum_{i=1}^{3} c_{ik} \beta_i^2 N_{ik} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.104</td>
<td>-0.104</td>
<td>-0.104</td>
<td>-684.52</td>
<td>-674.58</td>
</tr>
<tr>
<td>2</td>
<td>-0.203</td>
<td>-0.203</td>
<td>-0.203</td>
<td>-362.26</td>
<td>-144.78</td>
</tr>
<tr>
<td>3</td>
<td>-0.240</td>
<td>-0.240</td>
<td>-0.240</td>
<td>-1440.93</td>
<td>-587.00</td>
</tr>
<tr>
<td>4</td>
<td>-0.054</td>
<td>-0.054</td>
<td>-0.054</td>
<td>-272.67</td>
<td>-492.36</td>
</tr>
<tr>
<td>5</td>
<td>-0.049</td>
<td>-0.049</td>
<td>-0.049</td>
<td>-72.70</td>
<td>-132.30</td>
</tr>
<tr>
<td>6</td>
<td>-0.075</td>
<td>-0.075</td>
<td>-0.075</td>
<td>-524.18</td>
<td>-609.02</td>
</tr>
<tr>
<td>7</td>
<td>-0.102</td>
<td>-0.102</td>
<td>-0.102</td>
<td>-390.78</td>
<td>-470.82</td>
</tr>
<tr>
<td>8</td>
<td>-0.136</td>
<td>-0.136</td>
<td>-0.136</td>
<td>-497.17</td>
<td>-408.12</td>
</tr>
</tbody>
</table>

**Consistency Check**                             
-3518.99

Source: Calculated Estimates.

(3) Intercepts:

From (4.59) the individual-level intercepts are derived as

\[
\begin{bmatrix}
    a_{1k} N_{1k} + a_{2k} N_{2k} + a_{3k} N_{3k} + b_{1k} \alpha_{1k} N_{1k} + \\
    b_{2k} \alpha_{2k} N_{2k} + b_{3k} \alpha_{3k} N_{3k} + c_{1k} N_{1k} \text{var}(\varepsilon_{1k}) + \\
    c_{2k} N_{2k} \text{var}(\varepsilon_{2k}) + c_{3k} N_{3k} \text{var}(\varepsilon_{3k})
\end{bmatrix} = \lambda_k a
\]

(4.12)
To recover the micro intercepts (4.11), the following steps were taken: (a) estimation of the relationships between unadjusted $a_{1k}$, $a_{2k}$, and $a_{3k}$; and (b) recovery of consistent micro coefficients from the aggregate intercept.

(a) The $a_{ik}$ are estimated for the three types of farms and 8 regions using micro coefficients $b_{ik}$ (Table 7), $c_{ik}$ (Table 4.8), and Equations (3.47) through (3.49) with data on $E(m_{ik})$ and $\text{var}(m_{ik})$ and $y_{ik}$. $E(m_{ik})$ is defined to be expected adjusted gross margin (AGM) per acre where the AGM is equal to gross revenue plus producer withdrawals from his/her NISA account minus producer contributions. Expected AGM values are generated as an average over the 200 replicates and the ten-year simulation period for each of the 24 representative farms. The values on $E(m_{ik})$ and $\text{var}(m_{ik})$ are presented in Table 4.9.

Table 4.9. Expected Per-Acre Revenue and Revenue Variance on Representative G&O Farms.

<table>
<thead>
<tr>
<th>Region</th>
<th>$E(m_{1k})$</th>
<th>$E(m_{2k})$</th>
<th>$E(m_{3k})$</th>
<th>$\text{var}(m_{1k})$</th>
<th>$\text{var}(m_{2k})$</th>
<th>$\text{var}(m_{3k})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28.47</td>
<td>35.88</td>
<td>45.60</td>
<td>389.13</td>
<td>563.63</td>
<td>509.59</td>
</tr>
<tr>
<td>2</td>
<td>10.36</td>
<td>29.24</td>
<td>28.03</td>
<td>227.32</td>
<td>215.56</td>
<td>211.38</td>
</tr>
<tr>
<td>3</td>
<td>17.63</td>
<td>24.51</td>
<td>26.07</td>
<td>540.97</td>
<td>531.07</td>
<td>522.18</td>
</tr>
<tr>
<td>4</td>
<td>35.41</td>
<td>34.93</td>
<td>40.11</td>
<td>676.68</td>
<td>645.16</td>
<td>597.96</td>
</tr>
<tr>
<td>5</td>
<td>40.02</td>
<td>50.42</td>
<td>51.10</td>
<td>730.70</td>
<td>688.79</td>
<td>645.96</td>
</tr>
<tr>
<td>6</td>
<td>31.35</td>
<td>41.26</td>
<td>42.83</td>
<td>719.90</td>
<td>700.02</td>
<td>683.78</td>
</tr>
<tr>
<td>7</td>
<td>28.27</td>
<td>40.75</td>
<td>44.29</td>
<td>700.63</td>
<td>750.74</td>
<td>739.28</td>
</tr>
<tr>
<td>8</td>
<td>23.73</td>
<td>28.38</td>
<td>40.31</td>
<td>550.93</td>
<td>588.58</td>
<td>587.89</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

The estimated relationships between the unadjusted $a^*_{ik}$ may be represented as

$$a^*_{1k} = \theta_{1k} a^*_{2k}$$
$$a^*_{1k} = \theta_{3k} a^*_{3k}$$

(4.13)
The estimated \( a_{1k}^*, \theta_{1k} \) and \( \theta_{2k} \) are presented in Table 4.10.

### Table 4.10. The Unadjusted Individual-level Intercepts and Relationships Among Them.

<table>
<thead>
<tr>
<th>Region</th>
<th>( a_{1k}^* )</th>
<th>( a_{2k}^* )</th>
<th>( a_{3k}^* )</th>
<th>( \theta_{1k} )</th>
<th>( \theta_{2k} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>411.23</td>
<td>478.14</td>
<td>994.73</td>
<td>0.86</td>
<td>0.41</td>
</tr>
<tr>
<td>2</td>
<td>368.32</td>
<td>329.84</td>
<td>858.61</td>
<td>1.12</td>
<td>0.43</td>
</tr>
<tr>
<td>3</td>
<td>331.64</td>
<td>567.84</td>
<td>1206.22</td>
<td>0.58</td>
<td>0.27</td>
</tr>
<tr>
<td>4</td>
<td>251.31</td>
<td>567.80</td>
<td>1199.69</td>
<td>0.44</td>
<td>0.21</td>
</tr>
<tr>
<td>5</td>
<td>185.98</td>
<td>400.15</td>
<td>928.27</td>
<td>0.46</td>
<td>0.20</td>
</tr>
<tr>
<td>6</td>
<td>281.07</td>
<td>436.85</td>
<td>830.71</td>
<td>0.64</td>
<td>0.34</td>
</tr>
<tr>
<td>7</td>
<td>283.36</td>
<td>606.22</td>
<td>1104.17</td>
<td>0.47</td>
<td>0.26</td>
</tr>
<tr>
<td>8</td>
<td>354.96</td>
<td>491.39</td>
<td>957.27</td>
<td>0.72</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Source: Calculated Estimates.

(b) The aggregation-consistent individual intercepts \( (a_{ik}^*) \) are recovered using Equation (4.12), the aggregate intercept \( a \) from Equation (4.4), \( \theta_{1k} \) and \( \theta_{2k} \) from Table 4.10, \( N_{ik} \) from Table 4.1, \( b_{ik} \) from Table 4.7, \( c_{ik} \) from Table 4.8, \( \alpha_1, \alpha_2, \alpha_3 \), from estimated Equations (4.9). var \( (\varepsilon_{1k}) \), var \( (\varepsilon_{2k}) \), and var \( (\varepsilon_{3k}) \) from Table 4.6 and \( \lambda_{ik} \) from Table 4.4. Micro intercepts \( a_{ik}^* \) are recovered and estimated for three farm types and 8 regions. With respect to these individuals and aggregate intercepts a consistency check is performed by comparing the weighted sum of individuals intercepts with estimated aggregate intercept, \( a \). The results are presented in Table 4.11. As may be seen, the estimated aggregate intercept, \( a \), is consistent with the weighted sum of individuals intercepts. This value is equal to 18726360.

The weighted sum of these intercepts is consistent with the aggregate intercept \( a \). The results are presented in Table 4.11.
Table 4.11. The Consistent Individual Intercepts, $a_{ik}$

<table>
<thead>
<tr>
<th>Region</th>
<th>Crop Districts</th>
<th>$a_{1k}$</th>
<th>$a_{2k}$</th>
<th>$a_{3k}$</th>
<th>$a_{4k}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3BN</td>
<td>535.41</td>
<td>622.52</td>
<td>1295.12</td>
<td>3.589.807</td>
</tr>
<tr>
<td>2</td>
<td>7A</td>
<td>477.47</td>
<td>427.58</td>
<td>1113.03</td>
<td>770.449</td>
</tr>
<tr>
<td>3</td>
<td>2A</td>
<td>377.89</td>
<td>646.40</td>
<td>1374.42</td>
<td>3.123.729</td>
</tr>
<tr>
<td>4</td>
<td>6A</td>
<td>305.96</td>
<td>691.28</td>
<td>1460.58</td>
<td>2.620.124</td>
</tr>
<tr>
<td>5</td>
<td>7B</td>
<td>246.68</td>
<td>530.74</td>
<td>1231.23</td>
<td>704.060</td>
</tr>
<tr>
<td>6</td>
<td>5A</td>
<td>358.56</td>
<td>557.28</td>
<td>1059.72</td>
<td>3.240.905</td>
</tr>
<tr>
<td>7</td>
<td>8A</td>
<td>355.20</td>
<td>759.92</td>
<td>1384.12</td>
<td>2.505.463</td>
</tr>
<tr>
<td>8</td>
<td>9A</td>
<td>433.96</td>
<td>600.75</td>
<td>1170.32</td>
<td>2.171.822</td>
</tr>
</tbody>
</table>

Consistency Check 18.726.360

Source: Calculated Estimates.

By recovering the consistent individual intercepts and coefficients, the individual supply functions on 24 representative grains and oilseeds farms are estimated. These are presented in Table 4.12.
Table 4.12. Estimated Aggregation-Consistent Individual-Level Supply Functions

<table>
<thead>
<tr>
<th>Region</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$a_{ik}$</td>
<td>$b_{ik}$</td>
<td>$c_{ik}$</td>
</tr>
<tr>
<td>1</td>
<td>535.4</td>
<td>6.36</td>
<td>-0.104</td>
</tr>
<tr>
<td>2</td>
<td>477.5</td>
<td>8.00</td>
<td>-0.203</td>
</tr>
<tr>
<td>3</td>
<td>377.9</td>
<td>9.59</td>
<td>-0.24</td>
</tr>
<tr>
<td>4</td>
<td>305.9</td>
<td>4.55</td>
<td>-0.054</td>
</tr>
<tr>
<td>5</td>
<td>246.7</td>
<td>4.02</td>
<td>-0.049</td>
</tr>
<tr>
<td>6</td>
<td>358.6</td>
<td>5.02</td>
<td>-0.075</td>
</tr>
<tr>
<td>7</td>
<td>355.2</td>
<td>6.75</td>
<td>-0.102</td>
</tr>
<tr>
<td>8</td>
<td>433.9</td>
<td>7.46</td>
<td>-0.136</td>
</tr>
</tbody>
</table>

Source: Calculated Estimates

4.3 Policy Simulation at the Representative Farm Level

This section is in two parts. Section 4.3.1 describes the data, while in Section 4.3.2 is presented the empirical results on gross margin, adjusted gross margin, and government cost.

4.3.1 Data

In this thesis, a total of 24 representative grain and oilseed farms were constructed. These comprised one farm from each of eight different regions of the province and three revenue classes. The choice of these regions was dictated by the choice made in an earlier study by STHMN (1995), and which is used as a benchmark for comparison with the results in this thesis. The eight regions were:

Brown Soil Zone:

(1) crop districts 3AN, 3AS, 3BN, 3BS, 4A, and AB
(2) crop district 7A

Dark Brown Soil Zone:

(3) crop districts 1A, 2A, and 2B
(4) crop districts 6A and 6B
(5) crop district 7B

Black Soil Zone:

(6) crop districts 1B, 5A and 5B
(7) crop districts 8A and 8B
(8) crop districts 9A and 9B.

The number of grain and oilseed farms, represented by the sizes and locations used in this study, is given in Table 4.1. The average acreage of these representative farms in 1991 was estimated from National Farm Survey (NFS) data obtained from the Extraction System of Agricultural Statistics (ESAS). Total farm acreages are presented in Table 4.2. The crop rotations were determined as follows. The revenue attributable to each crop, reported in the taxfiler data, was divided by the 1991 crop price and yield to obtain the crop acreage. Wheat and durum revenues were combined in the taxfiler data as wheat revenue. Total wheat revenue was proportioned as wheat and durum using proportions based on the historical crop district wheat and durum acreages as reported in Agricultural Statistics (SDAF, 1992). All crop revenue attributable to wheat, barley or canola was treated as wheat revenue. The simulated output was adjusted to reflect any differential between total crop acreage resulting from the taxfiler data and cropped acreage reported in the NFS. The output variables (gross margin, government cost etc.) were calculated on a per cropped acre basis and then multiplied by the total cropped acreage reported in the NFS for that representative farm.
There are two types of variables used in the micro simulation analysis: (i) random (stochastic) variables, and (ii) deterministic (non-stochastic) variables. The sources and derivation of the values for these variables is discussed in the following two sub-sections.

(i) Stochastic Variables

The random (stochastic) variables assumed in the micro simulation analysis are prices and yields. The price assumptions are presented in Tables 4.13 to 4.15, while the yield assumptions are presented in Tables 4.16 to 4.18 respectively.

As discussed in Section 3.3.4, the price distribution for each commodity is assumed to be multi-variate log-normal. The estimated standard deviations of the log-normal errors in prices can be interpreted as providing an approximate percentage range around the mean price forecast within which actual values are expected to occur with a two-thirds probability. The means of the log-normal distributions in each year are set equal to the mean price forecasts for that year, obtained from the Medium Term Outlook (Agriculture Canada, 1993). These are presented in Table 4.13. The underlying variance-covariance matrix is estimated using prices from Agriculture Statistics (Saskatchewan Agriculture and Food, 1992), over a 15-year time period. The estimated variance-covariance matrix of commodity prices is represented by way of standard deviations of prices (Table 4.14) and correlations (Table 4.15). For this study, nominal prices are used as NISA is based on nominal prices.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat ($/t)</th>
<th>Barley ($/t)</th>
<th>Durum ($/t)</th>
<th>Canola ($/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>106</td>
<td>77</td>
<td>108</td>
<td>267</td>
</tr>
<tr>
<td>1995</td>
<td>121</td>
<td>90</td>
<td>125</td>
<td>261</td>
</tr>
<tr>
<td>1996</td>
<td>124</td>
<td>95</td>
<td>125</td>
<td>258</td>
</tr>
<tr>
<td>1997</td>
<td>122</td>
<td>89</td>
<td>124</td>
<td>249</td>
</tr>
<tr>
<td>1998</td>
<td>115</td>
<td>81</td>
<td>118</td>
<td>243</td>
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<td>1999</td>
<td>117</td>
<td>81</td>
<td>120</td>
<td>240</td>
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<td>2000</td>
<td>122</td>
<td>86</td>
<td>124</td>
<td>245</td>
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<td>2001</td>
<td>122</td>
<td>86</td>
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</tr>
<tr>
<td>2002</td>
<td>122</td>
<td>86</td>
<td>124</td>
<td>245</td>
</tr>
<tr>
<td>2003</td>
<td>122</td>
<td>86</td>
<td>124</td>
<td>245</td>
</tr>
</tbody>
</table>

Source: Medium Term Outlook, Agriculture Canada, 1993.


<table>
<thead>
<tr>
<th>Wheat ($/t)</th>
<th>Barley ($/t)</th>
<th>Durum ($/t)</th>
<th>Canola ($/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>21</td>
<td>35</td>
<td>41</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Barley</th>
<th>Durum</th>
<th>Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.00</td>
<td>0.91</td>
<td>0.93</td>
<td>0.53</td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td>1.00</td>
<td>0.87</td>
<td>0.50</td>
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<tr>
<td>Durum</td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.56</td>
</tr>
<tr>
<td>Canola</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: Calculated from price data in Agriculture Statistics, SDAF, 1992.
Crop yields are assumed to be distributed as a multi-variate normal, truncated at zero, and constant over time. The mean forecast yields are determined as the 10-year crop district average (Saskatchewan Agriculture and Food, 1992), and the variance-covariance matrix is calculated from Saskatchewan Crop Insurance Corporation Record of Production data as follows. Farmers with at least 15 years (10-years for canola) of data for each crop were selected and the variance and covariance of yields was calculated over time. The average, across farmers, of variance and covariance was used as an estimate of the variance-covariance matrix of the yield distribution for the individual representative farm. In some cases, the number of farmers meeting the 15 year criteria was too small to get a reasonable estimate of the covariance; in these cases, adjustments were made to include farmers with at least 10 years of data for each commodity.

The estimated means, standard deviations and correlations of yields are given in Table 4. 16, 4.17 and 4.18.

<table>
<thead>
<tr>
<th>Region</th>
<th>Wheat</th>
<th>Barley</th>
<th>Durum</th>
<th>Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.684</td>
<td>0.687</td>
<td>0.753</td>
<td>0.461</td>
</tr>
<tr>
<td>2</td>
<td>0.732</td>
<td>0.909</td>
<td>0.699</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>0.623</td>
<td>0.672</td>
<td>0.683</td>
<td>0.389</td>
</tr>
<tr>
<td>4</td>
<td>0.702</td>
<td>0.850</td>
<td>0.679</td>
<td>0.383</td>
</tr>
<tr>
<td>5</td>
<td>0.820</td>
<td>0.854</td>
<td>0.894</td>
<td>0.517</td>
</tr>
<tr>
<td>6</td>
<td>0.779</td>
<td>0.964</td>
<td>0.733</td>
<td>0.472</td>
</tr>
<tr>
<td>7</td>
<td>0.928</td>
<td>0.981</td>
<td>0.894</td>
<td>0.476</td>
</tr>
<tr>
<td>8</td>
<td>0.832</td>
<td>0.921</td>
<td>0.814</td>
<td>0.544</td>
</tr>
</tbody>
</table>

Table 4.17. Yield Standard Deviation Estimates (t/ac), Eight Regions of Saskatchewan.

<table>
<thead>
<tr>
<th>Region</th>
<th>Wheat</th>
<th>Barley</th>
<th>Durum</th>
<th>Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.23</td>
<td>0.32</td>
<td>0.28</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>0.23</td>
<td>0.32</td>
<td>0.28</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>0.23</td>
<td>0.32</td>
<td>0.28</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>0.23</td>
<td>0.33</td>
<td>0.25</td>
<td>0.17</td>
</tr>
<tr>
<td>5</td>
<td>0.23</td>
<td>0.33</td>
<td>0.25</td>
<td>0.17</td>
</tr>
<tr>
<td>6</td>
<td>0.22</td>
<td>0.32</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>7</td>
<td>0.22</td>
<td>0.32</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>8</td>
<td>0.22</td>
<td>0.32</td>
<td>0.25</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Source: Calculated from Saskatchewan Crop Insurance Corporation data (STHMN, 1995)
Table 4.18. Yield Correlation Matrices, by Region, Saskatchewan.

Regions 1, 2, and 3

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Barley</th>
<th>Durum</th>
<th>Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.00</td>
<td>0.58</td>
<td>0.77</td>
<td>N/A</td>
</tr>
<tr>
<td>Barley</td>
<td>1.00</td>
<td>0.60</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Durum</td>
<td>1.00</td>
<td></td>
<td>1.00</td>
<td>N/A</td>
</tr>
<tr>
<td>Canola</td>
<td></td>
<td></td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

Regions 4 and 5

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Barley</th>
<th>Durum</th>
<th>Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.00</td>
<td>0.59</td>
<td>0.77</td>
<td>0.44</td>
</tr>
<tr>
<td>Barley</td>
<td>1.00</td>
<td>0.60</td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>Durum</td>
<td>1.00</td>
<td></td>
<td>1.00</td>
<td>0.37</td>
</tr>
<tr>
<td>Canola</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Regions 6, 7, and 8

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Barley</th>
<th>Durum</th>
<th>Canola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1.00</td>
<td>0.57</td>
<td>0.71</td>
<td>0.64</td>
</tr>
<tr>
<td>Barley</td>
<td>1.00</td>
<td>0.41</td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td>Durum</td>
<td>1.00</td>
<td></td>
<td>1.00</td>
<td>0.46</td>
</tr>
<tr>
<td>Canola</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: Calculated from Saskatchewan Crop Insurance Corporation Data.

One other stochastic variable used in the micro simulation analysis is crop insurance premium. This is introduced as a percentage of (stochastic) market price and (stochastic) long-term yield.
(ii) Non-stochastic Variables

The non-stochastic variables appearing in the representative grain farm analysis include the expenses (costs) for the representative farms. These costs are variable cost and fixed cost. Most of the costs are taken from Extraction System of Agricultural Systems (ESAS) which uses sample taxfiler information for its taxation data estimates. This makes calculation under NISA very straightforward since each item in the taxation data in ESAS can be traced to a line number in the farm income tax return. These data are used as the baseline and line items of expenses are inflated using the Medium Term Outlook (Agriculture Canada, 1993) for farm inputs. Hence, most expenses are deterministic (non-stochastic).

4.3.2 Results

In this section is presented the results of the simulations and the analysis of NISA for the representative grains and oilseeds farms. For the later aggregation analysis, there are three output variables of interest: (i) gross margin, (ii) adjusted gross margin, and (iii) government cost.

(i) S-Ratios

The stabilizing potential of NISA, as measured by the S-ratios is summarized in Table 4.19. The first set of results are from the base scenario as developed in STHMN (1995). The second set of results involve the assumption of supply response at the individual farm-level to the policy rules.
Table 4.19. S-Ratios for Grains and Oilseeds Farms, by Farm Type and Region.

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Region</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Supply Response (STHMN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td></td>
<td>0.88</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
<td>0.87</td>
<td>0.88</td>
<td>0.86</td>
<td>0.86</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>0.88</td>
<td>0.89</td>
<td>0.90</td>
<td>0.89</td>
<td>0.87</td>
<td>0.88</td>
<td>0.86</td>
<td>0.87</td>
</tr>
<tr>
<td>Large</td>
<td></td>
<td>0.89</td>
<td>0.89</td>
<td>0.90</td>
<td>0.88</td>
<td>0.88</td>
<td>0.88</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>Supply Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>small</td>
<td></td>
<td>0.90</td>
<td>0.90</td>
<td>0.91</td>
<td>0.90</td>
<td>0.90</td>
<td>0.89</td>
<td>0.89</td>
<td>0.90</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>0.90</td>
<td>0.90</td>
<td>0.91</td>
<td>0.90</td>
<td>0.90</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>Large</td>
<td></td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

As may be seen from this table, the stabilizing effect over the ten-year simulation period of NISA allowing for supply response is slightly less than that of NISA without supply response (STHMN, 1995). The average reduction in variability of year-to-year AGM is around 10 percent. Differences across regions are very slight and well within the differences which may be caused by sample estimation. That is, the revenue classes may be so wide that the representative farms in different regions may be substantially different in size. This may lead to marginal differences in S-ratio measurements. Differences across farm types (revenue classes) are also very small.

(ii) Gross Margin and Adjusted Gross Margin

The level of financial support provided by the alternative policy options can be partly measured by the difference between the adjusted gross margin (AGM) and the gross margin (GM) under no policy. The remaining financial support accrues as additions to the producer's wealth through enhancements to the producer's average account balance. AGM is equal to GM plus producer withdrawals from his/her NISA account minus
producer contributions. In Table 4.20, are presented the gross margins per acre estimated for the different-sized representative farms in each region under supply response as estimated in the present study, and under no supply response as estimated in STHMN (1995).

<table>
<thead>
<tr>
<th></th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Supply Response</td>
</tr>
<tr>
<td>Farm Type</td>
<td>1   2   3   4   5   6   7   8</td>
</tr>
<tr>
<td>1</td>
<td>27.48 9.02 16.43 34.11 38.88 29.82 26.67 22.46</td>
</tr>
<tr>
<td>2</td>
<td>34.61 28.27 23.36 33.64 49.10 39.85 39.22 27.06</td>
</tr>
<tr>
<td>3</td>
<td>44.44 27.07 24.94 68.40 49.84 41.43 42.78 39.03</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

As may be seen from this table, the GM under supply response (SR) over the ten-year simulation period tend to be higher than under no supply response (NSR). For farm type 1 and 2 (small and medium revenue classes) over all regions, the GM per acre is higher than that with no supply response. However, for farm type 3 a couple of regions (4 and 8) suggest a higher GM per acre with NSR than with SR. One possible explanation for this is an error in the STHMN (1995) study. Note that the average gross margin/acre for large farms in region 4 is more than double that for mid-sized farms in the same regions. This is a questionable result and is out of line with the comparable results...
in other regions. In general, when supply response is permitted, the response tends to be positive. The reason will be discussed in the next chapter.

In Table 4.21 are presented the enhancements to gross margin per acre expected to be provided by NISA, first assuming no supply response and then assuming supply response is permitted.

<table>
<thead>
<tr>
<th>Table 4.21. Average Enhancement to Gross Margin from NISA ($/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
</tr>
<tr>
<td>Farm type</td>
</tr>
<tr>
<td>1                2                3                4                5                6                7                8</td>
</tr>
<tr>
<td>No Supply Response (STHMN)</td>
</tr>
<tr>
<td>1                0.99              1.34              1.21              1.30              1.45              1.53              1.62              1.27</td>
</tr>
<tr>
<td>2                1.27              0.97              1.47              1.29              1.32              1.41              1.53              1.32</td>
</tr>
<tr>
<td>3                1.27              0.97              1.47              1.57              1.26              1.41              1.51              1.28</td>
</tr>
<tr>
<td>Supply Response</td>
</tr>
<tr>
<td>1                0.70              1.25              1.17              1.16              1.17              1.31              1.36              1.26</td>
</tr>
<tr>
<td>2                0.65              1.15              0.96              1.13              1.03              1.16              1.30              1.28</td>
</tr>
<tr>
<td>3                0.45              -0.16             1.02              1.02              0.98              1.02              1.28              1.26</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

Although the whole-farm NISA increases the mean GM with both supply response and no supply response, it is only by a small amount. As may be seen from Table 4.21 the average enhancement to GM from basic NISA under no supply response over the ten-year simulation period is higher than under supply response. This implies less withdrawals and more wealth accumulation when supply response is assumed. This may be explained if the supply response scenario leads to a growth in gross margin, on average, over time relative to the case of no supply response. Such a result would imply,
on average, less withdrawals since these are triggered when gross margin falls relative to
the preceding five-year average. To check if there was, in fact, a difference in the rate of
growth of gross margin a trend difference of GM per farm of SR and NSR is estimated.
This was conducted by estimating simple linear trends of the average GM per farm over
the ten-year prospective simulation period. The trend coefficients are presented in Table
4.22.

Table 4.22. Trend Coefficients of the GM Per Farm over the Prospective Simulation

<table>
<thead>
<tr>
<th>Period.</th>
<th>Farm Type 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Supply Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-25.8</td>
<td>-7.7</td>
<td>-133.6</td>
<td>-140.8</td>
<td>-170.7</td>
<td>-262.1</td>
<td>-353.4</td>
<td>-454.2</td>
</tr>
<tr>
<td>2</td>
<td>-218.7</td>
<td>217.7</td>
<td>-220.2</td>
<td>-260.9</td>
<td>-307.7</td>
<td>-295.1</td>
<td>-599.9</td>
<td>-922.7</td>
</tr>
<tr>
<td>3</td>
<td>-497.4</td>
<td>273.2</td>
<td>-342.4</td>
<td>-485.4</td>
<td>-595.0</td>
<td>-719.2</td>
<td>-1242.1</td>
<td>-1532.2</td>
</tr>
<tr>
<td>Supply Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>801.6</td>
<td>210.1</td>
<td>-30.4</td>
<td>267.2</td>
<td>239.7</td>
<td>180.2</td>
<td>79.4</td>
<td>-557.6</td>
</tr>
<tr>
<td>2</td>
<td>1205.9</td>
<td>275.7</td>
<td>101.7</td>
<td>379.1</td>
<td>220.5</td>
<td>293.2</td>
<td>7.9</td>
<td>-820.0</td>
</tr>
<tr>
<td>3</td>
<td>707.8</td>
<td>1641</td>
<td>505</td>
<td>987.8</td>
<td>713.4</td>
<td>599.9</td>
<td>417.4</td>
<td>-972.5</td>
</tr>
</tbody>
</table>

Source: Estimates.

To obtain the trend differences the NSR coefficients were subtracted from the
respective SR coefficients. The trend differences are presented in Table 4.23.
### Table 4.23. The Trend Difference of GM Per Farm with SR and NSR.

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>827.4</td>
<td>217.8</td>
<td>103.2</td>
<td>408.0</td>
<td>410.4</td>
<td>442.3</td>
<td>432.8</td>
<td>-103.4</td>
</tr>
<tr>
<td></td>
<td>1424.6</td>
<td>58.0</td>
<td>321.6</td>
<td>640.0</td>
<td>528.2</td>
<td>588.3</td>
<td>607.8</td>
<td>102.7</td>
</tr>
<tr>
<td></td>
<td>2138.4</td>
<td>434.6</td>
<td>843.4</td>
<td>1473.2</td>
<td>1308.4</td>
<td>1319.1</td>
<td>1659.5</td>
<td>559.7</td>
</tr>
</tbody>
</table>

Source: Estimates.

As may be seen in Table 4.23, except for the small farm in region 8, all the trend differences are positive. This indicates less withdrawals and more wealth accumulation under the program if supply response is permitted. There are two reasons why we could expect a positive trend difference in GM per farm when moving to the SR scenario. They are associated with: (a) an increase in average gross margin per acre; and (b) an increase in average crop acres per farm. As seen in Table 4.20, the GM per acre under SR scenario over the ten-year simulation period is higher than under the NSR scenario. This is because GM per acre is defined as:

\[
\text{GM/acre} = \text{Crop Revenue/acre} - \text{Variable Costs/acre} - \text{Fixed Costs/acre}
\]

Crop revenue per acre and variable costs per acre are the same under both the SR and NSR scenarios. However under the SR scenario, as cropped area increases with NISA, so the fixed costs per acre decline and hence the GM per acre increases. The estimated GM per acre with SR for small, medium, and large farms over all regions were $33.6, $41.1, and $45.1 per acre respectively. However, the estimated GM per acre under the NSR scenario for the same farm types over all regions were $25.6, $34.4, and $42.2 per acre for small, medium, and large farms. This implies that the STHMN (1995) underestimated the GM per acre.
(iii) Government Cost

The average government transfers (on a per cropped acre basis) for each representative farm over the 10-year simulation period are presented in Table 4.24 first assuming no supply response and then assuming supply response is permitted.

<table>
<thead>
<tr>
<th>Region</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>No supply Response (STHMN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.72</td>
<td>1.69</td>
<td>1.51</td>
<td>1.76</td>
<td>2.00</td>
<td>1.97</td>
<td>2.00</td>
<td>1.51</td>
</tr>
<tr>
<td>2</td>
<td>1.74</td>
<td>1.73</td>
<td>1.50</td>
<td>1.73</td>
<td>2.02</td>
<td>1.95</td>
<td>2.05</td>
<td>1.55</td>
</tr>
<tr>
<td>3</td>
<td>1.82</td>
<td>1.69</td>
<td>1.48</td>
<td>2.53</td>
<td>1.98</td>
<td>1.98</td>
<td>2.07</td>
<td>1.57</td>
</tr>
<tr>
<td>Supply Response</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.62</td>
<td>1.75</td>
<td>1.51</td>
<td>1.77</td>
<td>2.01</td>
<td>2.00</td>
<td>2.03</td>
<td>1.52</td>
</tr>
<tr>
<td>2</td>
<td>1.76</td>
<td>1.77</td>
<td>1.33</td>
<td>1.75</td>
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<td>1.97</td>
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<td>1.56</td>
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<tr>
<td>3</td>
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<td>1.78</td>
<td>1.44</td>
<td>1.78</td>
<td>2.00</td>
<td>2.01</td>
<td>2.08</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

For most of the 24 representative farms represented in Table 4.24, the size of the average government transfer under supply response is very close to the case of no supply response. These results may be expected because, on a per acre basis, government costs under both SR and NSR is expected to be the same. With respect to the different farm types, there appears to be no systematic variation under both scenarios with NISA.

Government transfers are examined as a percent of gross margin in Table 4.25
Table 4.25. Average Government Transfers as a Proportion of Gross Margin.

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Region</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Supply Response (STHMN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>0.063</td>
<td>0.187</td>
<td>0.092</td>
<td>0.052</td>
<td>0.051</td>
<td>0.066</td>
<td>0.075</td>
<td>0.067</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.062</td>
<td>0.061</td>
<td>0.064</td>
<td>0.051</td>
<td>0.041</td>
<td>0.049</td>
<td>0.052</td>
<td>0.057</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.041</td>
<td>0.062</td>
<td>0.059</td>
<td>0.037</td>
<td>0.040</td>
<td>0.040</td>
<td>0.048</td>
<td>0.042</td>
</tr>
<tr>
<td>Supply Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>0.046</td>
<td>0.077</td>
<td>0.070</td>
<td>0.046</td>
<td>0.043</td>
<td>0.051</td>
<td>0.057</td>
<td>0.051</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.041</td>
<td>0.048</td>
<td>0.050</td>
<td>0.043</td>
<td>0.037</td>
<td>0.042</td>
<td>0.045</td>
<td>0.049</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.036</td>
<td>0.046</td>
<td>0.048</td>
<td>0.038</td>
<td>0.036</td>
<td>0.036</td>
<td>0.043</td>
<td>0.045</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

In 22 out of the 24 representative farms represented in Table 4.25, government transfers under the NSR scenario are higher than that under the SR scenario. The only variation occurs in a few of the large grain farms where the effect of negative gross margins becomes a factor. Although gross margin may go negative, government contributions cannot. This means that the average gross margin per acre may fall relative to the average government contribution, resulting in an average government contribution about 5 percent of average gross margin for the NSR scenario and above 3 percent under the SR scenario respectively. Government transfer tends to vary inversely with the size of the gross margin per acre. The estimated government costs as a proportion of GM under the SR scenario for small, medium, and large farms over all regions were 0.055, 0.044, and 0.041 respectively. However, the estimated government transfers as a proportion of GM under the NSR scenario for the same farm types over all regions were 0.08, 0.05, and 0.046 for small, medium, and large farms. Thus, for example, it is highest for the small grain farm (farm type 1) in region 2 (0.187 under the NSR scenario versus 0.077) which has the
smallest gross margin per acre ($9.02 per acre under the NSR scenario versus $22.64 per acre under the SR scenario) and it is lowest for the large grain farm (farm type 3) in region 4 for no supply response and in region 6 for supply response which have the largest gross margin per acre (no supply response 68.40 and supply response 55.66). These results are as expected.

4.4 Policy Simulation at the Aggregate-Level

The purpose of this section is to present the results of the aggregation analysis when supply response is allowed. The aggregation analysis assumes limited heterogeneity between farms in Saskatchewan based on geographic location (i.e. region) and revenue class (small, medium and large) for grain and oilseed farms (small, medium and large). There are three sets of results presented: (i) the aggregate effects of NISA on disposable income from grain and oilseed farms in Saskatchewan; (ii) the aggregate costs of NISA to the government; and (iii) the aggregate effects of NISA on crop area on G&O farms in Saskatchewan. These results are compared to results obtained in a previous study by STHMN (1995) in which no supply response was assumed.

These results are discussed in sections 4.4.1, 4.4.2, and 4.4.3 respectively.

4.4.1 Effects on Aggregate Agricultural Income.

Aggregate agricultural income as measured by gross margin was first obtained from the simulation model assuming no NISA policy. This was used as the benchmark against which to compare the effects of NISA. Aggregate gross margin over the 200 replicates and the ten-year simulation period was calculated for each of the 24 representative farms. These were aggregated together by multiplying the number of farms in the region of the province represented by the corresponding representative farm. These were then aggregated across regions, using the description in Table 4.1 to obtain aggregate results on a soil zone basis. The results of this calculation for both the SR and NSR scenarios are
presented in Table 4.26. As may be seen from this table, the aggregate effect of NISA on disposable income in the grain and oilseed sector of Saskatchewan under the supply response model (present study) is larger than that under no supply response.

The values in Table 4.26 are not intended to be forecasts of agricultural income in Saskatchewan over the simulation period (1994-2003). The methodology is one tailored to assess the aggregate effects of farm income supports rather than forecast farm income. Furthermore, it should be recalled that in this study the definition of gross margin is the one used for the purposes of calculating the withdrawals from NISA and not the net income as measured by Statistics Canada. However, it is interesting to compare the results in Table 4.26 for both the SR and NSR scenarios.

**Table 4.26. Aggregate Gross Margin on G&O Farms in Saskatchewan (million $)**

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Brown</th>
<th>Dark Brown</th>
<th>Black</th>
<th>Province</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Supply Response (STHMN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>43.4</td>
<td>44.4</td>
<td>57.5</td>
<td>145.3</td>
</tr>
<tr>
<td>2</td>
<td>83.7</td>
<td>88.3</td>
<td>135.2</td>
<td>307.2</td>
</tr>
<tr>
<td>3</td>
<td>66.0</td>
<td>136.2</td>
<td>167.5</td>
<td>369.7</td>
</tr>
<tr>
<td>Total</td>
<td>193.1</td>
<td>268.9</td>
<td>360.2</td>
<td>822.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply Response</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.9</td>
<td>57.2</td>
<td>83.2</td>
<td>202.3</td>
</tr>
<tr>
<td>2</td>
<td>101.5</td>
<td>112.5</td>
<td>164.9</td>
<td>378.9</td>
</tr>
<tr>
<td>3</td>
<td>74.4</td>
<td>125.3</td>
<td>195.7</td>
<td>395.4</td>
</tr>
<tr>
<td>Total</td>
<td>237.8</td>
<td>295.0</td>
<td>443.8</td>
<td>976.6</td>
</tr>
</tbody>
</table>

Source: Simulation Model
Differences across soil zones and farm types between the SR scenario and the NSR scenario are high except for the dark brown soil zone and farm type 3 (large). The estimated aggregate GM with SR for small, medium, and large farms over all soil zones were $202.3, $378.9, and $395.4 millions, respectively. However, the estimated aggregate GM with NSR for the same farm types over all soil zones were $145.3, $307.2 and $369.7 for small, medium, and large farms. The aggregate GM over all farm types and soil zones (at province level) with both SR and NSR were $976.6 and 822.2 millions respectively. This represents an increase of 19 percent when supply response is permitted. The explanation for this is as follows. Under the SR scenario, crop area is permitted to vary in response to adjusted gross margin per acre. The NISA program raises AGM and this in turn increases crop area. Aggregate gross margin is the product of crop area and gross margin per acre. Since crop area increases under the SR scenario so does aggregate gross margin.

In Table 4.27 are presented the average aggregate enhancement effects of NISA on disposable grain and oilseed income over the ten-year simulation period under the NSR and SR scenarios. In these tables, the aggregate results are presented for no supply response and supply response for different farm types (small, medium, and large) and by geographic location.
Table 4.27. Enhancement to Aggregate Gross Margin on G&O farms in Saskatchewan Due to NISA (million $).

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Geographic Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brown</td>
</tr>
<tr>
<td>No Supply Response (STHMN)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.9</td>
</tr>
<tr>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>6.7</td>
</tr>
<tr>
<td>Supply Response</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

In Table 4.27 the effect of NISA on increasing annual disposable income under both supply response and no supply response can be seen. The aggregate increase was found to about $24.9 millions in the case of supply response and $31.6 millions in the case of no supply response. As may be seen the aggregate enhancement with NSR is higher than that of SR. These results are consistent with the results at the farm-level. Of this increase, the largest portion was in the black soil zone and the smallest increase was in the brown soil zone. In fact, the gains in annual income in the black soil zone were double those (under no supply response) and larger (under supply response) than the gains in the other two soil zones combined. Government transfers under NISA may show up either as increased annual disposable income or as wealth increases through additions to the program account. An estimate of the total financial transfers provided by the
government are discussed in the next section which provides estimates of the aggregate government costs.

4.4.2 Effects on Aggregate Government Costs

In the present study, the government costs of NISA include only the direct program costs (government contributions and interest bonus). These include, government contributions which amount to 2 percent of eligible net sales and an interest bonus on producer contributions of 3 percent.

In Table 4.28 are presented the average aggregate government costs of NISA over the ten-year simulation period. In this table, the aggregate results are presented for different farm types and by geographic location.

<table>
<thead>
<tr>
<th>Table 4.28. Aggregate Government Cost of NISA in Saskatchewan (million $).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geographic Location (Soil Zone)</strong></td>
</tr>
<tr>
<td>Farm Type</td>
</tr>
<tr>
<td>No Supply Response (STHMN)</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Supply Response</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Source: Simulation Model.
Table 4.28 shows that the average annual aggregate government transfer is estimated to be about $42.9 million when supply response is permitted. This is almost identical to the estimate ($42.4 million) under the NSR scenario. In all farm types and geographic locations except one, the incorporation of supply response resulted in very little change in aggregate. The exception is for large farms in the dark brown soil zone.

In the aggregate, the soil zone which benefits most from NISA under both assumptions about supply response is the black soil zone. This confirms the results of Section 4.4.1.

To provide some perspective at the individual level, government costs are presented on a per acre basis by farm type and soil zone in Table 4.29. As may be seen, the average per acre government costs under the NSR scenario over all soil zones and all farm types is slightly higher than that under the SR scenario. This is because of the higher crop area under the SR scenario than under the NSR scenario.

<table>
<thead>
<tr>
<th>Table 4.29.</th>
<th>Per Acre Government Cost of NISA in Saskatchewan ($/acre).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic Location (Soil Zone)</td>
<td></td>
</tr>
<tr>
<td>Farm Type</td>
<td>Black</td>
</tr>
<tr>
<td>No Supply Response (STHMN)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.72</td>
</tr>
<tr>
<td>2</td>
<td>1.74</td>
</tr>
<tr>
<td>3</td>
<td>1.80</td>
</tr>
<tr>
<td>Supply Response</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.65</td>
</tr>
<tr>
<td>2</td>
<td>1.77</td>
</tr>
<tr>
<td>3</td>
<td>1.83</td>
</tr>
</tbody>
</table>

Source: Simulation Model.
Thus, the per acre government costs with both NSR and SR are $1.89 and $1.79 respectively. These results are consistent with the results at the farm level.

4.4.3 Effects on Aggregate Crop Area

Total crop area on grains and oilseeds farms in each region \( Y_k \) is estimated using the methodology that was developed in chapter 3. The STHMN analysis provides a consistency check by comparing the aggregate crop area determined from the aggregation exercise with actual aggregate crop area obtained from official statistics. For grain and oilseed farms, in the three soil zones, the estimated aggregate crop areas as a percentage of actual areas, were 87, 82, and 75 percent for the brown, dark brown and black soil zones respectively. In order to compare the results of the present study with STHMN, the values of GM and AGM and government costs were adjusted by the extent of these discrepancies.

Crop area associated with brown, dark brown and black soil zones \( Y_{(B)} \), \( Y_{(DB)} \), and \( Y_{(BL)} \) respectively will be estimated as follows:

\[
Y_{(B)} = Y_1 + Y_2
\]

\[
Y_{(DB)} = Y_3 + Y_4 + Y_5
\]

\[
Y_{(BL)} = Y_6 + Y_7 + Y_8
\]

In Table 4.30 are presented the average aggregate effects of NISA on crop area. In this Table, the aggregate results are presented for different farm types and by geographic location (soil zones).
Table 4.30. Aggregate Crop Area Due to Supply Response to NISA in Saskatchewan (million acres)

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Brown</th>
<th>Dark Brown</th>
<th>Black</th>
<th>Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.87</td>
<td>1.81</td>
<td>2.32</td>
<td>6.00</td>
</tr>
<tr>
<td>2</td>
<td>2.40</td>
<td>3.09</td>
<td>3.79</td>
<td>9.38</td>
</tr>
<tr>
<td>3</td>
<td>1.53</td>
<td>3.17</td>
<td>4.14</td>
<td>8.84</td>
</tr>
<tr>
<td>Total</td>
<td>5.80</td>
<td>8.07</td>
<td>10.25</td>
<td>24.22</td>
</tr>
</tbody>
</table>

Source: Simulation Model.

The total crop area under NISA under the NSR scenario was estimated to be 23.41 million acres but under the SR scenario was estimated to be 24.22 million acres. Thus, by not allowing for supply response the STHMN study may underestimate the effect of basic NISA on crop area by about three percent.

In Table 4.31 are presented the average aggregate crop areas under the SR scenario when no NISA is assumed. This provides the appropriate benchmark for estimating the effects of NISA on crop area. In this table, the aggregate results are presented for different farm types and different soil zones.

Table 4.31. Aggregate Crop Area Due to the SR Scenario under No NISA (million acres)

<table>
<thead>
<tr>
<th>Farm Type</th>
<th>Brown</th>
<th>Dark Brown</th>
<th>Black</th>
<th>Province</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.76</td>
<td>1.74</td>
<td>2.20</td>
<td>5.70</td>
</tr>
<tr>
<td>2</td>
<td>2.28</td>
<td>2.99</td>
<td>3.68</td>
<td>9.95</td>
</tr>
<tr>
<td>3</td>
<td>1.49</td>
<td>3.01</td>
<td>4.07</td>
<td>8.57</td>
</tr>
<tr>
<td>Total</td>
<td>5.53</td>
<td>7.74</td>
<td>9.95</td>
<td>23.22</td>
</tr>
</tbody>
</table>

Source: Estimates
Table 4.31 shows that the average aggregate crop area under no NISA is estimated to be about 23.26 million acres. As may be seen in Tables 4.30 and Table 4.31 in all farm types and soil zones the incorporation of supply response with NISA result in a higher average crop area than with no NISA. The basic NISA raised acreage planted to the four major crops by three percent.

With respect to empirical illustration there are a number of limitations that are discussed in chapter 6 of this study.

4.5 Summary

In this chapter the multi-stage aggregation methodology that was developed in chapter 3 was applied to an illustrative empirical analysis. The illustration chosen was the NISA program in Saskatchewan. The aggregation-consistent individual supply functions were utilized to analyze the effects of NISA at the aggregate level since the policy impacts directly at the individual level. Two policy alternatives (no policy and NISA) were assumed at the individual and aggregate levels under a supply response scenario and a no supply response scenario. This was accomplished by examining: (1) adjusted gross margin; (2) gross margin; (3) government costs; and (4) crop area. The specific implications of this illustrative empirical analysis are discussed in the next chapter. However, for now, it is useful to note a couple of general points about the analysis. Firstly, the methodology can be used in an empirical setting and may provide useful insights into the policy effects of the new generation of Canadian farm income stabilization programs. Secondly, however, I would not be too reliant on the particular numerical results of the analysis. For example, the aggregate supply function (from MNL, 1994) may be open to some criticism as not being the most representative of the Saskatchewan situation. In addition, fairly simplistic assumption have been made about the degree of homogeneity of farms in a particular region and this may bias the results. It
is important to keep in mind that the analysis in chapter 4 is viewed as illustrative rather than definitive. Before placing too much faith in the empirical results we would want to conduct some fairly extensive sensitivity analysis.
CHAPTER 5

IMPLICATIONS OF THE ANALYSIS

5.1 Introduction

NISA-type whole-farm income support programs differ from some earlier support programs in Canada (e.g., commodity-based price support) in that the unit of measurement is the individual farm rather than units of the commodity. From a methodological perspective, price supports can be analyzed solely by reference to aggregate data, generally using aggregate supply and demand curves. This is not possible with whole-farm income support schemes, where policy rules on contributions and withdrawals operate at the individual farm level. In order to analyze the latter type of policy rule one must work at both the aggregate and individual-farm level and must ensure consistency between the two.

The primary purpose of this thesis has been to develop as appropriate methodology for analyzing the aggregate effects of such income support programs. This was accomplished in chapter 3. In chapter 4 was presented an illustrative discover what we can learn about the methodology from its implication in the empirical analysis. The empirical example was chosen because it allows us to build on and correct a fundamental deficiency in earlier work by STHMN (1995) which attempted to estimate the aggregate (provincial-level) effects of a NISA-type whole farm income support program for Saskatchewan. The fundamental deficiency in that earlier work was that the authors did not allow for supply response to the program. In the illustrative empirical analysis of chapter 4, the aggregate impact of the individual-farm-based NISA-type programs assumed using the methodology that was developed in chapter 3.

The implications and interpretations of these results are discussed in sections 5.2 through 5.4.
5.2 Methodological Results and Implications

The major implications with respect to the methodological perspective are summarized as follows:

1. All aggregate coefficients either on expected per acre net revenue or net revenue variance per acre Equations 3.72 and 3.73 depend on micro variables because the coefficients $a_{ik}$ and $b_{ik}$ are dependent on these variables. Hence, even if the micro coefficients $a_{ik}$, $b_{ik}$, and $c_{ik}$ remain unchanged after the period $t=T$, the macro coefficients will be influenced by the behavior of the micro variables after this period through Equations 3.68.

2. The macro parameter $a$ (Equation 3.71) does not only depend on the "corresponding micro parameters" $a_{ik}$, but also on the other "non corresponding micro parameters" $b_{ik}$ and $c_{ik}$. For the NISA illustration of the preceding chapter this means that the intercept of Equation 4.3 depends upon the way in which individual representative farms react, for instance in terms of expected net returns.

3. The macro parameters $b$ and $c$ do not depend on the micro parameters $a_{ik}$, but they depend on all parameters $b_{ik}$, not only on the corresponding micro parameters $b_{ik}$ and $c_{ik}$. This means that, for instance, the parameter describing the influence of expected net return per acre and variance revenue per acre on total crop area is dependent on the way in which individual representative farms react.

4. Full micro-macro modeling of the aggregation methodology that was implemented in chapter 3 as an initial attempt appears to be necessary for a successful characterization of the impacts of individual heterogeneity in aggregating policy options in terms of distributional and equity effects.

Micro- and macro-model complementarities can be discussed from several perspectives including model specification, model simulation and model results. In the present study, individual level supply functions were specified which were consistent with the aggregate level supply function. Owing to the difficulties of achieving
consistency with non-linear specifications (according to Stoker, 1993), linear supply functions were specified. One can verify that linear individual models are the only models that give recoverability for broad ranges of distributions. Stoker (1993) mentioned that the foundation of the aggregate model rests on its connection to individual behavior parameters which are recoverable from the aggregate model. He pointed out that, without such a recoverability property, the connection between the aggregate level and individual level is not clear. Therefore, in order to recover the micro level parameters from the aggregate level, linear supply functions at both levels were assumed.

Considerable complications arise if one wants to aggregate an entire system of simultaneous linear micro-relations to a smaller system of simultaneous linear macro-equations. Such a system contains as many "endogenous" variables as there are equations. If such a system is written in its original economic form, each endogenous variable will in general appear as a function of other endogenous variables and of some exogenous variable. Then it is called a system of structural equations. One can also write each endogenous variables as a function of exogenous variables only, by eliminating the other endogenous variables. Then we have a system of reduced-form equations. So there will be four systems: One of micro structural equations, one of micro reduced-form equations, one of macro structural equations and one of macro reduced-form equations. The properties that were postulated for the macro structural equations are usually chosen on the analogy of those that were given by the economic theory of the micro structural equations. In the present study a linear structural equation for both the micro- and macro-models were specified, in which crop area was assumed to be a function of the first two moments of net return per acres.

An important model specification problem is that of prices being endogenous at the macro level but exogenous at the micro level. In this study, such a problem is sidestepped because it is reasonable to assume that prices are exogenous at both levels in Canada (mentioned in chapter 3). Revenues were generated using randomly selected
prices and yields from specified multivariate probability distributions. In any given year, cross-commodity correlations exist within prices and within yields, but prices and yields were assumed to be independent of each other. The rationale for this is that prices are basically determined in international markets which are related, but Saskatchewan production variability is not sufficiently large enough to influence world prices. Thus, prices were assumed to be exogenous at both micro- and macro-models.

The second part of modeling aggregation-consistent individual level supply response model was micro-simulation. In particular, the micro-simulation methodology began with a full model of the individual representative farms in which the effects of policy rules were captured at the individual level and then the aggregate values of the interested variables were simulated by adding up across all farm types and geographical locations. By extending the model of representative farm through micro-simulation we can examine directly the impact of policy changes upon individual farms. Micro-simulation methodology has the potential for the most realistic representation of policy rules which operate at individual farm level.

The third area of micro- and macro-level complementarity is in the results themselves. The aggregation methodology, discussed in chapter 3, is used to obtain the macro level policy effects. This methodology forces consistency between the micro- and macro levels.

The literature review has focused on the specification of supply response considering the question of consistency between the micro and macro levels. The main reason for being concerned with this issue was for analysis of the aggregate effects of government policy which operates according to rules which apply at the level of the individual farmer.
5.3 Estimated Aggregation-Consistent Individual-Level Supply Functions

To estimate an aggregation-consistent individual-level supply function, the aggregation methodology developed in chapter 3 was applied to the basic NISA as an illustration. The results of the application of this methodology are summarized in Tables 4.7 through 4.12.

As seen in Table 4.12 all coefficients of the individual-level supply functions have the expected signs and are consistent with the aggregate coefficients. In particular, the estimated coefficients show that farms' expected per acre revenue for the \( i^{th} \) farm type and \( k^{th} \) region has a positive impact on the \( i^{th} \) farm acreage, that is, acreage response functions have positive slopes. Also, the revenue per acre variance (risk variable) associated with farm supply functions has a negative coefficient in individual farm acreage response equation.

At the farm level, the coefficients on revenue per acre and variance per acre revenue across farm types were the same because equal responsiveness across farm types was assumed with respect to a change in expected per acre revenue as well as variance per acre revenue. However, each representative farm type had different coefficients across regions. As seen in Tables 4.7, 4.8, and 4.11 the consistency was illustrated by the consistency check which was imposed. The estimated coefficients are reasonably as expected because they have the expected signs and the weighted sum of the coefficients is consistent with the aggregate coefficients. For instance, from Table 4.12, an increase of one percent in the expected per acre revenue of each farm type resulted in higher crop area by 6.36 acres in region one and an increase of one percent in the revenue per acre variance reduced acreage supply by about 0.104 acre. The highest impact with respect to revenue per acre and revenue variance was in region 3 and the lowest impact with respect to revenue per acre was in region 5. These individual-level supply functions are used as inputs into the policy simulation analysis. Since the NISA-type program is expected (at the individual level) to raise expected revenue per acre and lower expected revenue.
variance per acre it is expected that the introduction of individual-level supply functions in the analysis would raise crop area when the policy is in place. This is unlike the earlier STHMN (1995) analysis which did not allow for supply response.

5.4 Policy Simulation at the Representative Farm Level

The results of incorporating the estimated aggregation-consistent individual-level supply functions into the simulation model and the analysis of NISA for 24 representative grains and oilseeds farms with both supply response (SR) and no supply response (NSR) were presented in chapter 4 in Tables 4.18 through 4.24. These were for three output variables of interest: (1) gross margin; (2) adjusted gross margin; and (3) government costs.

The level of financial support provided by the basic NISA can be partly measured by the difference between the AGM and the GM. The remaining financial support accrues as additions to the producer's wealth through enhancements to the producer's average account balance. As seen in Table 4.19, the GM per acre under SR scenario over the ten-year simulation period is higher than under the NSR scenario. This is because GM per acre is defined:

\[
GM/\text{acre} = \text{Crop Revenue/acre} - \text{Variable Costs/acre} - \text{Fixed Costs/acre}
\]

Crop revenue per acre and variable costs per acre are the same under both the SR and NSR scenarios. However under the SR scenario, as cropped area increases with NISA, so the fixed costs per acre decline and hence the GM per acre increases. The estimated GM per acre with SR for small, medium, and large farms over all regions were $33.6, $41.1, and $45.1 per acre respectively. However, the estimated GM per acre with NSR for the same farm types over all regions were $25.6, $34.4, and $42.2 per acre for small, medium, and large farms. We should be careful not to make too much of these numbers since the
empirical analysis is not rigorous. However, the direction of difference between the results in this thesis and in STHMN (1995) suggest that the latter study may have underestimated the GM per acre.

From a methodological perspective, the differences between farm types and region in terms of GM per acre may give evidence for heterogeneity in individual responses, and suggests that accounting for limited heterogeneity in the aggregation methodology may make aggregate parameter estimates more consistent with estimates from individual level.

As seen in Table 4.20 the whole-farm NISA increased the mean GM per farm in every farm type and in each region only by a small amount. Under the SR scenario and NISA, the enhancement amounts to 2.6% of GM. This falls short of the average enhancement, over all regions and farm types, under the NSR scenario which amounts to 3.9% of GM. This was explained by way of the positive trend difference of GM between the SR and NSR scenarios. Under the SR scenario, withdrawals are less and enhancements to the producer's annual disposable income are also less. The estimated enhancement with SR for small, medium, and large farms over all regions were $1.2, $1.1, and $0.86 per acre respectively. However, the estimated enhancement with NSR for the same farm types over all regions were $1.34, $1.32, and $1.34 per acre for small, medium, and large farms. The percentage enhancement tends to vary inversely with size of farm. Table 4.22 shows that the trend difference over all regions varies directly with size of farm. The trend difference over all regions for small, medium, and large farms are $342.3, $533.9, and $1217 respectively. This implies the less trend difference the greater enhancement to annual gross margin.

The average government transfers, on a per cropped acre basis for each representative farm over the 10-year simulation period were found to be about the same under both the SR and NSR scenarios (Table 4.23). Under the SR scenario, the size of the average transfer over 8 regions amounts to $1.78, $1.78, and $1.81 per acre for the size of small, medium, and large farms respectively. Under the NSR scenario, the corresponding
average transfers over 8 regions were identical at $1.78, $1.78, and $1.81 per acre. This suggests that the exclusion of supply response from the analysis does not unduly bias the estimates of government transfers on a per acre basis. One corollary to this result is that by ignoring supply response, the STHMN analysis would tend to underestimate the wealth accumulation effects of NISA, on a per acre basis. This is because: (i) government transfer is the same; (ii) has to end up either as disposable income or in producers account as wealth accumulation; (iii) if enhancement to disposable income is overestimated by STHMN methodology; then enhancement to wealth accumulation must be underestimated. In policy discussions, one criterion used for comparing the size of government transfers across enterprises or industry groups is the size of the transfer as a percentage of value added in production. This may give a sense in terms of distributional impacts or equity. Hence, it might be useful to examine government transfers as a percentage of GM. These were presented in chapter 4. The percentage government transfers were found to be larger under the NSR scenario than under the SR scenario. This is expected because, while government transfers per acre are about the same under both scenarios, the gross margin per acre tends to be underestimated when supply response is not permitted. This suggests that the percentage government transfers resulting from NISA will tend to be underestimated if supply response is not taken into account. As may be seen in Table 4.24 the government transfers as a percent of GM tend to vary inversely with the size of farm. For instance with SR, the average government contributions as a percentage of average GM over 8 regions for the size of small, medium, and large farms are 0.05, 0.044, and 0.041 respectively.

5.5 Policy Simulation at the Aggregate Level

At the farm level, the coefficients on revenue per acre and variance per acre revenue across farm types were the same because equal responsiveness across farm types
was assumed with respect to a change in expected per acre revenue as well as variance per acre revenue.

The aggregate impacts of basic NISA under the SR scenario were presented in Tables 4.26 through 4.28. These impacts included: (1) the aggregate effects of NISA on disposable income of grains and oilseeds farms; (2) the aggregate costs of NISA to the government; and (3) the aggregate effects of NISA on crop area. These findings were compared to the STHMN's findings. The implications and interpretations of these results are discussed in following subsections 5.4.1 through 5.4.3.

5.5.1 Effects on Aggregate Agricultural Income

Aggregate agricultural income as measured by gross margin was first obtained from the simulation model assuming no policy (NISA). This was used as the benchmark against which to compare the effects of policy. Aggregate gross margin over the 200 replicates and the ten-year simulation period was calculated for each of the eight regions and presented in chapter 4. As may be seen in Table 4.25 the aggregate effect of NISA, with SR, on disposable income of the grains and oilseeds sector in Saskatchewan was higher than that of NSR. The effect of NISA in increasing annual disposable income was presented in chapter 4. The aggregate increase was found to be about $977 million in the case of supply response and $822 million in the case of no supply response. Again, we should be careful not to place too much alliance on these particular values. However, this finding does suggest that STHMN may have underestimated the aggregate effect of NISA on disposable income by not incorporating supply response into their analysis.

The enhancement to aggregate disposable income, with SR, was estimated to be lower than that of NSR. The aggregate enhancement was found to be about $25 million in the case of SR and $32 million in the case of no supply response. This is consistent with the farm-level results and can be explained by the positive trend difference of aggregate GM per farm between the SR and NSR scenarios. The positive trend difference resulted
in less aggregate withdrawals and consequently resulted in less aggregate enhancement to disposable income. This is consistent with the results at the farm level, and suggests that ignoring supply response when analyzing NISA-type programs may lead to an overestimate of the enhancement to annual aggregate disposable farm income. This could be a concern if one were interested in increasing disposable income in the rural economy as a whole. The other aspect of these results is what they mean to the aggregate savings of farmers. Ignoring supply response may results in an underestimate of the wealth accumulation effects of the NISA program. Under the NSR scenario, average aggregate year-ending account balance in Saskatchewan was estimated to be $129.6 million, while under the SR scenario it was estimated to be $165.4 million.

5.5.2 Effects on Aggregate Government Costs

In the thesis, the government costs of NISA included only the direct program costs such as government contributions and interest bonus. These included the government contribution which amounts to 2% of eligible net sales and a 3% interest bonus on producer contributions. The aggregate government transfers from basic NISA over the 200 replications and the ten-year simulation period were presented in Table 4.27 of chapter 4. As seen in this table the aggregate effect of NISA, under the SR scenario, on government costs for the grains and oilseeds farms in Saskatchewan was found to be slightly higher (42.9 million) than that under the NSR scenario (42.4 million). These results suggest that ignoring supply response is not likely to seriously bias aggregate impact of basic NISA on government cost. This is because, with NISA, the aggregate crop area is higher under the SR scenario than under the NSR scenario. This higher crop area results in higher eligible net sales which in turn results in a higher aggregate government cost.
5.5.3 Effects on Aggregate Crop Area

The aggregate effect of NISA on crop area was presented in Table 4.29 of chapter 4. This finding suggests that during ten-year simulation period, the basic NISA was estimated to raise aggregate acreage planted to four major crops (by 3%). Of course, in STHMN (1995) there was a zero impact of NISA on aggregate crop area. This size of the area increase estimated in the present study was modest and reflects the fact that basic NISA is a fairly small program as far as subsidy programs go. This result suggests that from the prospective of national concern over misallocation of resources or international concerns over production distortions NISA is quite minor. Of course, if NISA were enhanced, the story might change. The methodology developed in this thesis could be readily adopted to estimate the aggregate production enhancing effects of an enhanced NISA.
CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Summary

In this section each of the thesis objectives, as described in chapter 1, are restated. For each objective the associated results are summarized.

The overall objective of this study was to develop an appropriate aggregation methodological approach for analyzing the effects of the whole-farm program (i.e. NISA) on supply at both aggregate and individual levels and to ensure consistency between the two. In order to analyze this problem, three basic methodological objectives were undertaken. These were: (i) estimation of the individual representative supply functions (micro-level) that are consistent with an estimated aggregate supply function; (ii) simulation of the effects of the policy at the individual level; and (iii) aggregation of the effects of the policy simulated at the individual level.

The first objective was to estimate an aggregation-consistent individual-level supply function. A methodology developed in chapter 3 was applied in an illustrative empirical analysis to NISA in chapter 4. The empirical application chosen builds on earlier work by STHMN (1995).

Table 4.12 illustrates aggregation-consistent individual-level supply functions. The individual supply functions on 24 representative grains and oilseeds farms were estimated. On the basis of the selected model and its assumptions set out in chapter 3, the coefficients on per acre expected revenue and revenue per acre variance across farm types (small, medium, and large) had expected signs and were consistent with the aggregate-level coefficients. Tables 4.7, 4.8, and 4.11 illustrate the consistency check between the individual-level coefficients and the aggregate-level coefficients.

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The second objective was to simulate the impact of the whole-farm program on the individual level, given the estimated individual-level supply functions. The results were for three major output variables of interest: (i) gross margin (GM); (ii) adjusted gross margin (AGM); and (iii) government costs. These were assessed under two scenarios: (i) supply response (SR); and (ii) no supply response (NSR).

Table 4.20 illustrates the estimated GM per acre under both SR and NSR scenarios for grain and oilseed farms in Saskatchewan in 8 regions and for three types of farms (small, medium, and large). As seen in that table, the GM under supply response to be higher than under no supply response. This is because GM is equal to price times yield times area minus variable costs and minus fixed costs. When supply response is allowed, the area will change over the simulation period and this reduces the fixed cost and leads to an increase in GM per acre in the SR scenario. However, with the NSR scenario, the area is constant over time and does not affect the GM per acre. This suggests that STHMN (1995) may have underestimated the GM per acre.

The whole-farm NISA increased the mean GM for every farm type and in each region only by a small amount. The enhancement (AGM-GM) under the NSR scenario over the ten-year simulation period is higher than under the SR scenario. As discussed in chapter 5, the smaller average enhancement under the SR scenario is due to smaller and/or fewer withdrawals and larger and/or more enhancements to the producer's average account balance when supply response is taken into account.

Under the SR scenario, the size of the average government transfer over 8 regions was about the same as under the NSR scenario. This suggests that ignoring supply response, as in STHMN (1995) may not have seriously biased the results on a per acre basis. However, the size of the average government transfer per farm was found to be larger under the SR scenario than under the NSR scenario. This is because the positive supply response to NISA creates more net eligible sales and more net eligible sales creates
more contributions. This suggests that the STHMN (1995) study may have underestimated the average annual government costs of NISA.

The third objective was to aggregate the effects of the policy over the various farm sizes and regions of Saskatchewan. The aggregate impacts of the basic NISA under the SR and NSR scenarios were laid out in chapter 4, with respect to disposable income; the aggregate costs of NISA to the government; and the aggregate effects of NISA on crop area. These findings were compared to the STHMN’s findings.

Aggregate gross margin under the SR and NSR scenarios were estimated to be about $980 and $820 million respectively. This finding suggests that ignoring supply response in an analysis of NISA effects could result in a downward bias in the estimated aggregate gross margin. This negative bias arises because NISA is expected to have a supply-enhancing effect. However, the enhancement to aggregate disposable income (due to NISA) under the SR scenario, was estimated to be lower ($25 million) than that under the NSR scenario ($32 million). This reflects the effect of NISA on enhancing GM/acre over time which occurs in the SR scenario but not in the NSR scenario. The rising GM/acre over time results in fewer withdrawals under the SR scenario and hence a smaller enhancement to GM. This suggests that ignoring supply response results in an upward bias in the aggregate disposable income.

The aggregate impact of the basic NISA on government costs under both the SR and NSR scenarios were found to be very similar. This suggests that ignoring supply response results in a no significant bias in aggregate government cost. Under the SR scenario, the aggregate impact of the basic NISA on crop area was found to be modestly positive, as expected (about 3 percent). Of course, in the STHMN study, there was zero change in total crop area.

In sum, the illustrative empirical exercise in this thesis builds on and corrects a fundamental deficiency in earlier work by STHMN (1995) which attempted to estimate the aggregate (provincial-level) effects of a NISA-type whole farm income support
program for Saskatchewan. The fundamental deficiency in that earlier work was that the authors did not allow for supply response to the program. In this thesis supply response was incorporated into the analysis using a three-component methodology, as desired in chapter 3.

6.2 Conclusions

This study represents an attempt to develop an appropriate methodology for analyzing the aggregate effects of a particular type of policy rule. This type of policy rule is one for which the unit of observation is the individual rather than the commodity. When the unit of observation is the commodity, the policy can generally be analyzed at the aggregate level by using aggregate supply and demand functions (e.g., price support policies). However, when the unit of observation is the individual, this is no longer appropriate. One must explore the impacts on the individual as a prelude to exploration at the aggregate level. To this end, the present study has attempted to develop a methodology which ensures consistency between the farm level and the aggregate level.

The major conclusions with respect to the methodological perspective are summarized as follows: (1) The methodology developed in this study represents an initial attempt to provide a full micro-macro modeling with supply response which is required for analyzing the whole-farm income support programs, where policy rules on contributions and withdrawals operate at the individual farm level. Aggregation over individual farms under limited heterogeneity was modeled with supply response in a consistent fashion. This methodology is applicable to the applied questions of the whole-farm program for the aggregate level, but retains the features of modeling behavior at the individual-level. Because of the consistency (the bridge) between individual and aggregate levels, the linkage permits individual behavioral responses to be consistent with the aggregate response. (2) An important benefit of such a micro-macro simulation approach is that it provides a tool for analyzing effects of very specific rule changes
which operate at the individual level on aggregate measures. For example, one could use this methodology for looking at aggregate effects of changing NISA contribution levels and withdrawal rules. (3) The methodology is envisaged to be widely applicable. Although the methodology was applied to an analysis of NISA, the same basic approach could conceivably be used to analyze the aggregate effects of other policy options that may affect supply and operate at the individual farm level. These may include GATT70 and VAISA (proposed alternatives to NISA) as well as crop insurance.

While the main conclusions concern the methodology, there were also some tentative conclusions that can be made from the empirical analysis. The analysis examines the implications of not incorporating supply response in a previous NISA study by STHMN (1995). The results suggest that ignoring supply response may: (1) result in a downward bias in the estimated GM per acre and aggregate gross margin; (2) result in an upward bias in the estimated enhancement to gross margin from the program; and (3) underestimate (i.e., ignore) the positive effect on crop area.

6.3 Limitations of the Study

The purpose of this study was to build an aggregation-consistent individual-level methodology for grains and oilseed farms in Saskatchewan to analyze the impacts NISA-type whole-farm income support policies. However, there are a number of limitations in the study. These are as follows:

(1) The most important limitation of the empirical application was the lack of availability of farm level agricultural data. To estimate an aggregation-consistent individual-level supply function it is necessary to have information on the responsiveness of different farm types (farm size) to a change in expected per acre revenue as well as the variance of revenue. However, the supply responsiveness of different-sized farms at the farm-level is not available. In the present study, the farm-level supply functions had slope coefficients which were identical across farm sizes in a given region. This is because equal
responsiveness across farm types was assumed with respect to both a change in expected revenue per acre and revenue variance per acre. With farm-level information on the differential response of different-sized farms to a change in the first two moments of net revenue per acre, this restrictive assumption could be relaxed.

(2) A second limitation is the estimated aggregate supply function that was used in the empirical analysis. This study used MNL’s (1994) aggregate acreage supply function that they estimated for western Canada which may or may not be a good approximation of an aggregate supply function for grains and oilseeds for Saskatchewan.

(3) A third limitation is that this study focused on grains and oilseeds farms while NISA could be extended to livestock, other crops, other provinces, and the enhanced NISA of the Saskatchewan program.

(4) A fourth limitation is the choice of representative farms. The representative farms were of crop districts, which may or may not be representative of a region. More fundamentally, the assumption of limited heterogeneity means that all farms within a region were assumed to be homogeneous. Reducing the size of the homogeneous regions would likely improve the precision of the results.

(5) The methodology that was developed is sensitive to the functional form of the aggregate and individual supply functions. In the present study the linear function was assumed. It would be worthwhile exploring the sensitivity of the results to alternative functional forms.

**6.4 Recommendations for Further Research**

With a view to extending this methodology, the suggested areas for further research are:

(1) To examine what happens to the aggregation bias under alternative specifications, using the same data for the same time period. (2) To move from limited heterogeneity to more heterogeneity to find the impacts of varying this assumption on the policy effects
on both individual and aggregate-levels. Further study could disaggregate further in terms of crops, farm types and regions.

(3) To estimate an aggregate supply function for grains and oilseeds for Saskatchewan and redo the analysis for new set of results.

(4) To extend the model for examination of other NISA-type policy options.

(5) To extend the model to examine of Crop Insurance versus NISA as alternatives approaches to stabilizing farm income.
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