An Econometric Analysis of the Cash Receipts from Crops in South Dakota

Dennis James Senger

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AN ECONOMETRIC ANALYSIS OF THE CASH RECEIPTS
FROM CROPS IN SOUTH DAKOTA

BY

DENNIS JAMES SENGER

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Economics, South Dakota
State University
1979

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AN ECONOMETRIC ANALYSIS OF THE CASH RECEIPTS
FROM CROPS IN SOUTH DAKOTA

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Thesis Adviser

Date

Head, Economics Department

Date
ACKNOWLEDGEMENTS

Writing the credits is in a sense more difficult for me than any other single part of this work. I only hope that the statement, "So many have given so much for so little!" does not apply in this case.

It is much more than protocol which requires that I thank Dr. Kim, whose patient and inquisitive mind asked and answered many more questions than you will see addressed here.

Various members of the Economics Department, who either through classroom or coffeeroom lectures, have contributed by unveiling some of the secrets of economics in action.

The graduate students have made the experience bearable. My parents have believed so long, that it was necessary. My wife, Cynthia--who typed early into the morning--and children have done what only they could do, made the memory a happy one.

DJS
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Chapter 1

INTRODUCTION

Few studies have focused on the issue of the aggregate relationship between farm income, personal income, and Gross State Product. Experienced researchers are left with scant quantitative tools to measure the impact of changing prices and supplies on the level of economic activity in the state. Yet, the relative importance of the agricultural sector to the entire South Dakota economy should not be underestimated.

Johnson has forecast:

... for 1979 that 30 percent of the Gross State Product would come from the agricultural sector of the state's economy. For this reason and the fact that output in the remaining sectors is somewhat dependent on agriculture as support activities the outlook for the state depends to a considerable extent on agriculture ... Thus, we do not feel it necessary to revise these projections down as sharply as may be warranted on a national level. [Even though] Tourism will be down significantly. [8, p. 4]

The following table should help illustrate the point. In the years 1974 through 1977, the farm industry contributed between 7.0 to 18.6 per cent of South Dakota's total personal income, compared with 1.7 to 2.6 per cent for the entire nation for the same years. This dependence on the agricultural sector has caused the state's growth rate of total personal

---

1 Conflicting terminology has arisen for measures of the aggregate level of economic activity. Farm income, for example, has been defined differently by the Department of Commerce and the Department of Agriculture. This author has seen personal income divided into total, several levels of disposable, permanent, and, of course, per capita all of the above. Only Gross State Product appears to unambiguously refer to the total market value of goods and services produced in a state. The reader is warned to carefully watch which measure is under discussion in this and other works.
TABLE 1

PERSONAL INCOME, SELECTED COMPONENTS
SOUTH DAKOTA AND UNITED STATES, 1974-1977a

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>South Dakota</td>
<td>United States</td>
<td>South Dakota</td>
<td>United States</td>
<td>South Dakota</td>
</tr>
<tr>
<td>(1) Total Personal Income b</td>
<td>3,329</td>
<td>1,147,257</td>
<td>3,410</td>
<td>1,248,631</td>
</tr>
<tr>
<td>(2) Percentage growth rate in (1)</td>
<td>-3.8</td>
<td>9.8</td>
<td>5.3</td>
<td>8.8</td>
</tr>
<tr>
<td>(3) Farm Personal Income b</td>
<td>604</td>
<td>29,733</td>
<td>492</td>
<td>28,881</td>
</tr>
<tr>
<td>(4) Percentage growth rate in (3)</td>
<td>-42.4</td>
<td>-17.2</td>
<td>-18.6</td>
<td>-2.9</td>
</tr>
<tr>
<td>(5) Relative Share of Farm</td>
<td>18.6</td>
<td>2.6</td>
<td>14.4</td>
<td>2.3</td>
</tr>
</tbody>
</table>

a Source: Bureau of Economic Analysis, United States Department of Commerce.
b Numbers in millions of current dollars.
income to fluctuate around the national average in the same direction as the state's farm personal income growth rate has varied around the national average. Therefore, it is worthwhile to analyze the dominant role of the agricultural sector in the state economy in terms of farm income.

Several approaches have been used in the analysis of macroeconomics of regions, states, and nations. Each of these approaches has its own advantages and disadvantages, both conceptually and when applied to empirical work. Three of the most popular approaches for macroeconomic analysis will be considered separately below.

One popular approach has been the construction and application of input-output models. Input-output models delineate the economic interdependence of the economy's industries by showing all of the interindustry transactions required to satisfy the final demand for goods and services. This approach provides an accurate and detailed picture of the activity of an economy during the period for which it is constructed. Two formidable disadvantages of input-output models are the static framework based upon one period's transactions, and the requirement of considerable data not generally available without high collection costs. The University of South Dakota's Business Research Bureau constructed an input-output model for South Dakota, but the results were generally considered unreliable for the above reasons, primarily the problem with data collection.

Another approach frequently chosen for estimation of farm income is the construction of a time-series model. This method assumes that variables move in a cyclical or trend pattern. The future movements
of a variable are predicted solely on the past behavior of that variable. This naive assumption would place no credence in the idea that price or supplies have a direct influence in the level of farm income for any year. Since the data requirements are easily met, it provides an attractive, low-cost procedure.

The third approach considered for this study was the use of single-equation regression models. In this class of models, "... the variable under study is explained by a single function (linear or nonlinear) of explanatory variables." [12, p. xiv]. With this equation one can predict the response of the variable under study to changes in the explanatory variables. The single-equation regression technique does not have the formidable data requirements of the input-output model, but it does require more data than the time-series model. From a conceptual viewpoint it is more attractive than the view that the variable is unchanged by all surrounding events except the passage of time.

It is the intent of this research effort to fill a void left in the previous research efforts. This study will not be concerned with how farmers adjust production in response to price or government policies. The attempt will be made to adapt single equation regression models to the examination of how the level of prices and supplies affect a major portion of the income the farming sector receives, specifically the crop cash receipts.

The specific objectives of this study are as follows:

1. To construct an econometric model of South Dakota crop receipts.
2. To demonstrate the model's use as a forecasting tool.
These objectives will be considered in the following manner. The recent steps in the identification of the economic activity of the farming sector in the macroeconomy and one attempt at modeling the South Dakota economy without explicit treatment of agriculture will be reviewed in Chapter 2. The conceptual framework upon which the study is based is provided in Chapter 3. The empirical results of the equations are presented in Chapter 4. The results of the full model simulations and forecasts are shown in Chapter 5. Suggestions for further work and limitations of the study are presented in the closing chapter.
Chapter 2

LITERATURE REVIEW

Econometric analysis in the agricultural sector has a long and distinguished history, dating back to before 1920. The early work was done in the specification of supply and demand functions for individual commodities, either for a region or for the nation as a whole. The aspect of how the farming sector was turning these commodities into income was largely left unattended.

The research into farm income generation is of much more recent origin. The first attempts reviewed below addressed the agricultural sector as another sector in a macromodel of the United States economy. These models were constructed because large-scale national econometric models either ignored the farm sector or simply linked farm variables to non-farm variables. The next step was the modeling of the farm sector on a state level, again arising due to neglect by state econometric models.

In 1959, Cromaty [5] initiated the construction of agricultural sector models which linked with national macroeconomic models. His model was designed to complement the model earlier constructed by Klein and Goldberger of the United States economy. He identified twelve product categories, of which eleven had sufficient homogeneity to estimate supply and demand relationships.

Cromaty related the carry-over from any year to the available supply, current price, and the expected supply for next year. Prices were determined as a function of government demand under loan or
purchase agreement, available supply, and various demand side factors. The categories were then aggregated into a prices received index and a physical production index. Gross farm income was estimated as follows²:

\[
(1) \quad R = \sum_{i=1}^{11} (Y_{i2} \times Y_{i1}) + r_{12};
\]

where \( R \) = gross farm income from production;

\( r_{12} \) = farm income from category twelve;

\( Y_{i2} \) = price received for category \( i \);

\( Y_{i1} \) = production of category \( i \).

Production expenses were then estimated, and income from additional sources was exogenously added to the model to obtain net income for farm proprietors.

Cromaty used available supply, defined as production plus beginning inventories, for his carry-over and price relations, but then related gross income to only the current production levels and price. His crop sector was estimated on a crop year basis, and he left unaddressed the question of how these were made compatible with the calendar year estimates for the livestock groups. The preface notes, "... many of the relations are being re-examined and re-estimated." [4, p. 556], but the results of this process were not found for inclusion in this report.

Fox [6] followed with an agricultural submodel to the Brookings Quarterly Model of the United States. The agricultural sector was divided into the two food groups, crops and livestock, and other

²All equations from cited references retain the original notation of the author(s).
products. The submodel was divided into two blocks of equations. The first eight equations focused on the determination of farm product prices. The second block of seven equations determined the component parts of net farm income.

Retail demand functions for the two food groups were estimated as functions of time, Koyck lags,3 and per capita income. Supply functions for marketing services were functionally related to time, Koyck lags, and an index of marketing costs. Price indexes were obtained by subtracting the marketing services from the retail value of the two groups. These indexes, along with exogenous price indexes for non-food commodities, were related to an overall index of prices received by farmers.

The next block determined farm income. Gross farm income minus imputed rent was estimated as a function of the prices received index, farm product marketings index, and a Koyck lag. Imputed rental income is simply related to a Koyck lag. Production expenditures, depreciation, and net changes in inventory values were estimated in terms of time trends and Koyck lags. An identity combining the above, closed the block to estimate net farm income.

The Fox model relied heavily on autoregressive terms in all of the equations. In a sense, his model is a close approximation to a time-series model. In actual practice the submodel was not used for later policy simulation of the entire Brookings model.

3Koyck lag is a geometric lag model assuming that the weights of the lagged explanatory variables are all positive and decline geometrically over time.
Chase Econometric Associates [4] have modeled the agricultural sector of the United States. Their model was essentially a quarterly model with one exception described below. The model was divided into three blocks. Crop acreages were estimated in the first block on an annual basis. The second block converts to a quarterly basis and estimated quantities and prices for crops and livestock. The third block contained estimates for gross and net farm income and for prices received by farmers.

The crop sector considered five crops. Acreage from each crop depended on various variables for exogenous acreage allotments or restrictions, the relative price of the crop to either fertilizer or substitute crops, and sometimes acreage of competing crops. The exogenous yield was multiplied by acreage to obtain production. The quarterly change in stocks was primarily related to production and exports. Price equations generally included support prices, price of substitutes, per capita consumption and income, stocks, and exports.

The livestock sector was broken into five groups. The stocks of cows and of hogs were lagged prices relative to feed grain prices. Slaughterings of cows and of hogs were also related to price variables. Prices for the two groups were related to per capita consumption, per capita disposable income, and, for hogs, the price of beef and poultry. The supplies of dairy products, poultry, and eggs were related to their own prices and prices of feed grains and supplements. The prices of the last three groups were related to supplies, prices of substitutes, and per capita disposable income.
The structure of the Chase model provided for an easy transition into the estimation of farm income. The disaggregation into commodities and the quarterly time period was useful for relating how receipts were generated. The quarterly price and the change in stocks were related to cash receipts in the crop sector. For livestock, price and slaughtering or supplies determined cash receipts.

Brookings [2] attempted to adapt the methods of the above national models to the problem of a state model of farm income. The submodel arose out of dissatisfaction with the original one equation specification of the farm sector in his state model of Mississippi. His model identified seven groups, for which he estimated cash receipts. He noted that price was determined by outside market forces, and the state will act as a competitive firm moving along its supply curve to an equilibrium level of output.

Brookings based his analysis on the concept of real receipts, defined as quantity sold in constant dollar terms. He then formed groups in which one product dominated each of the first six groups. He estimated the real receipts from each group through a variety of supply equations, which mostly consisted of lagged prices and Koyck lags. The real receipts were multiplied by the appropriate price index to determine nominal receipts from each group.

The rest of the model to determine gross and net farm income was treated in the second block. This block was characterized by Koyck lags and time trends as explanatory variables.

Brookings' model placed heavy reliance on autoregressive terms in nearly all his equations. In addition, the real receipts concept
does not account for carry-in stocks. The relative composition of the
groups is assumed fixed over time.

Rubida [13] adapted an annual econometric model of the United
States to South Dakota. His model consisted of three main blocks
which determined private gross state product, income and employment,
and taxes and government transfers. The model did not treat agricul-
ture or any other industry separately. Private gross state product
was estimated by ten equations determining aggregate demand from the
consumption and investment sectors.

Rubida's model shows one method which has been used to depict
the actions of the South Dakota economy. The empirical results of
the model were not satisfactory. Only 24 per cent of the regression
coefficients were shown to be statistically significant at the 10 per
cent level. The fact that the structure of South Dakota differs from
the nation's was cited as a major qualification of the study. Rubida,
like others before him, placed a heavy emphasis on autoregressive
terms.

Lang's [10] study followed Rubida's and, in a sense, laid some
of the groundwork for this research effort. His study was not a model
as the term has been used here, but was a conceptualization of the
need to adequately define the agricultural economy of South Dakota
before the rest of the economy can be explained. He discussed the
revenue flows to the farming sector, and explained their importance
in defining the actions of the other sectors.

The Business Research Bureau of the University of South Dakota
provides estimates from the South Dakota Econometric Model [8]. The
original model delineated the economy by industry into eleven components of output, employment, and wage rate blocks. The output block was summed to yield Gross State Product. The employment and wage rate blocks together yielded wage and salary income, and the other components of personal income were estimated. The original model left agricultural output exogenous due to the poor performance of the single equation estimate.

The model was updated to provide estimates of prices for eleven commodities, simply relating South Dakota price to the national price. Livestock marketings for five groups were estimated using various prices, stocks, and range conditions. Cash receipts for livestock were an identity, price times marketing. Acreage planted and harvested for six major crops was related to price, diverted acres, and weather variables. Yields were estimated as functions of weather, time, price, and acreage planted. Cash receipts for these crops were estimated as follows:

\[(2) \quad \ln CCR_{kt} = f(\ln CP_{kt}, \ln CP_{kt-1}, \ln CP_{kt-2}, \ln PC_{kt})\];

where \( CCR_{kt} = \) crop cash receipts, \( k^{th} \) commodity, \( t^{th} \) year;
\( CP_{kt} = \) crop production, \( k^{th} \) commodity, \( t^{th} \) year;
\( PC_{kt} = \) crop price, \( k^{th} \) commodity, \( t^{th} \) year.

Cash receipts for the miscellaneous groups were related to the total receipts of the sector.

The South Dakota Econometric Model was an improvement over the Brookings model in the respect that the estimation method did not assume a fixed composition of groups. In addition, it did not
completely ignore production activities from preceding years. The method chosen to handle this problem, distributed lag of production, apparently has not predicted as well as hoped. Ralph Brown, chief architect of the South Dakota Econometric Model, on March 4, 1978 stated in a telephone conversation that he hoped to specify the inventory question differently. No information of this process was obtained at the time of this writing.

From a brief review of the previous studies on farm income at the state or national level, it is apparent that the unique characteristics of the agricultural sector and the generation of farm income should be taken into account for constructing a state or national econometric model. If the relative importance of agriculture to a state is as great as in South Dakota, it is necessary to take a closer look at the generation of farm income as a prerequisite to analyzing the state economy. As an initial step to a state econometric model, the generation of income and revenue flows to the farm sector is discussed in the following chapter.

\[
\begin{align*}
\text{I} & = \text{imputed income from rent and home consumption; } \\
\text{NI} & = \text{net farm income; } \\
\text{PE} & = \text{production expenses; } \\
\text{AVI} & = \text{net value change in inventories. }
\end{align*}
\]

As indicated in Chapter 2, this study will only consider the cash receipts from crops. Under the definition described above, the receipts from crops include only the value of quantities sold off the farm. Income from crops fed on the farm to livestock is included as part of livestock income.
Chapter 3

THEORETICAL FRAMEWORK

In order to model the farm sector of a state, it is first necessary to specify the process by which the farm sector generates its income. This analysis revolves around the revenue flows which determine cash receipts, the major component of farm income. While different definitions of state farm income exist in practice, this study will consider farm income as defined by the Department of Agriculture as follows:

\[
\begin{align*}
(1) & \quad GFI = CCR + LCR + SP + II; \\
(2) & \quad NFI = GFI - PE + \Delta I;
\end{align*}
\]

where

- $GFI = \text{gross farm income;}$
- $CCR = \text{crop cash receipts;}$
- $LCR = \text{livestock cash receipts;}$
- $SP = \text{subsidy payments;}$
- $II = \text{imputed income from rent and home consumption;}$
- $NFI = \text{net farm income;}$
- $PE = \text{production expenses;}$
- $\Delta I = \text{net value change in inventories.}$

As indicated in Chapter 1, this study will only consider the cash receipts from crops. Under the definition described above, the receipts from crops include only the value of quantities sold off the farm. Income from crops fed on the farm to livestock is included as part of livestock income.
Since cash receipts constitute the major income item, the derivation of cash receipts provides a logical basis for analyzing state farm income. But a state, or any aggregate concept, is an artificial construct. The process of generating cash receipts on an aggregate level is a summation of all the individual processes of the producers in the state. The individual producer is where a study of the generation of cash receipts must begin.

Consider the profit maximizing farmer who has no inventories, but has the land to produce some crops during the current year. Assuming that his expected discounted return on the new production exceeds his expected discounted variable costs of production, he will plant his acreage to some combination of crops, depending on relative prices and crop rotational patterns. Further assuming that he has no options other than selling the entire produce during the current year, his receipts from one crop, for instance \( i \), will be:

\[
(3) \quad CR_i = P_i \times Q_{ik};
\]

where \( CR_i \) = farm cash receipts, \( i^{th} \) crop; \( P_i \) = price, \( i^{th} \) commodity; \( Q_{ik} \) = quantity produced, \( i^{th} \) crop, \( k^{th} \) farmer.

As mentioned above, each farmer produces a variety of crops. The composition of their production plans will not be the same in all cases due to different expectations about prices, different rotational patterns, and different soils, among other reasons. However, summing over all of the \( N \) farmers in the state who produce the \( i^{th} \) crop, total receipts for the state for the \( i^{th} \) crop will be:
(4) $\text{TCR}_i = \sum_{k=1}^{N} \text{CR}_{ik}; \quad k = 1, 2, \ldots, N;$

where $\text{TCR}_i =$ state total cash receipts, $i^{th}$ crop.

Then, summing over all $M$ crops produced in the state, total crop cash receipts for the state will be:

(5) $\text{TCCR} = \sum_{i=1}^{M} \text{TCR}_i; \quad i = 1, 2, \ldots, M;$

where $\text{TCCR} =$ state total crop cash receipts.

It is generally recognized that prices for crops are a given constant for producers, since the individual farmer (and probably even an entire state) will not have a sufficient impact on supplies to violate this assumption of the perfect competition model. If this is true, substituting equation (3) into equation (4), and reworking slightly, yields:

(6) $\text{TCR}_1 = \sum_{k=1}^{N} Q_{ik}^p\cdot$

From (6) it appears that the forecasting of cash receipts, the stated purpose of this study, reduces to estimating the price and aggregate production of each crop and applying (5) to obtain total crop receipts.

This naive approach is similar to the method that Brookings [2] applied to his model of the Mississippi farm sector. It is easy to recognize that the assumptions made at the onset do not reflect reality in two important ways: (1) the farmer typically enters the year with some carry-in stocks, and (2) the farmer has other options available for the disposal of his product. Taking into account these additional
factors, equation (3) must be modified as follows:

\[ CR_i = P_i \times Q^S_{ik}, \]

where \( Q^S_i \) = quantity sold off the farm, \( k^{th} \) farmer.

Now using (7) and (4) the new identity for generating cash receipts from a crop is:

\[ TCR_i = P_i \sum_{k=1}^{N} Q^S_{ik}. \]

Thus it appears that, if price and aggregate sales for each crop are estimated, the forecasting of receipts from the crop sector will follow by applying (8) and (5).

The problem that is encountered with this reasoning is that data are not available for price or marketings of crops on an annual basis. The choice must be made between following the above reasoning, using data for crop years, or providing a slightly modified formulation consistent with the calendar year data which are available.

It was determined to modify the formulation to the calendar year time frame. Two factors played a decisive role in this determination. First, there are four distinct crop years for the major crops grown in South Dakota. Second, the expansion of this model to other sectors, such as livestock or the entire state economy, will be impeded by differing time frames.

The model selected for determining cash receipts draws upon Cromaty's [5] concept of available supply. Available supply is that quantity which is available for disposal by the farm sector during the time period under consideration. The available supply concept
recognizes that the quantity marketed can come from carry-in stock and current year production. In addition it allows for the three separate impacts these two sources of supply can have on an annual cash receipts model, namely, (1) enter into current year's crop receipts, (2) become part of next year's crop receipts, or (3) be used in other activities on the farm.

One alteration must be made to Cromatyi's original specification, due to the inavailability of annual price data for individual commodities. It was necessary to group the crops into homogeneous groups which have a useable price index compiled for the sample period. Three groups have such an index: (1) food grains (wheat and rye), (2) feed grains (corn, oats, barley, sorghum, and hay), and (3) oil crops (soybeans and flaxseed). The other crops were treated separately as a miscellaneous group.

Using the available supply concept, cash receipts no longer fit into the price time quantity identity. Cash receipts for each group are now functionally related to the price index and the available supply from each of the crops in the group as follows:

\[ TCR_j = f(P_j, S_{ij}, \varepsilon_j); j = 1, 2, 3; \]

where \( TCR_j \) = state total cash receipts, \( j^{th} \) group;
\( P_j \) = price index, \( j^{th} \) group;
\( S_{ij} \) = available supply, \( i^{th} \) crop, \( j^{th} \) group;
\( \varepsilon_j \) = a stochastic element, \( j^{th} \) group.

The above relation applies only to the first three groups. The composition of the miscellaneous group varies greatly. No suitable
price index exists. The hypothesized model for this group simply relates the group's receipts to the combined receipts from the other crops, as an indication of general growing conditions and price levels. This function may be represented as follows:

\[ (10) \quad \text{TCR}_{\text{misc}} = f\left( \sum_{j=1}^{3} \text{TCR}_j, \varepsilon_{\text{misc}} \right); \]

where \( \text{TCR}_{\text{misc}} \) = state total cash receipts, miscellaneous group.

There is little empirical or theoretical basis for the selection of any particular functional form for the above relations. Perhaps the two most common forms used in empirical work are the multiplicative and the linear functions. Both of these functional forms can be made compatible with ordinary least squares regression techniques.

The multiplicative form of equations (9) and (10), hereafter referred to as Model I, becomes respectively:

\[ (11) \quad \text{TCR}_j = a_0 p_j a_1 \pi S_{ij} a_{1+i} e_j; \]

and

\[ (12) \quad \text{TCR}_{\text{misc}} = a_0 \left( \sum_{j=1}^{3} \text{TCR}_j \right) a_1 e_{\text{misc}}. \]

Equations (11) and (12) can be linearized by taking logarithms as follows:

\[ (13) \quad \ln\text{TCR}_j = \ln a_0 + a_1 \ln p_j + \pi a_{1+i} \ln S_{ij} + \ln e_j; \]

and

\[ (14) \quad \ln\text{TCR}_{\text{misc}} = \ln a_0 + a_1 \ln( \sum_j \text{TCR}_j ) + \ln e_{\text{misc}}. \]
the regression coefficients of this form represent the elasticity with respect to the independent variables.\footnote{Elasticity is defined as the percentage change in the independent variable divided by the percentage change in one of the dependent variables \textit{ceteris paribus}. There will thus be one such elasticity measure for each dependent variable. Caution should be exercised when interpreting these measures.}

The linear form of equations (9) and (10), hereafter called Model II, becomes respectively:

\begin{align}
(15) \quad TCR_j &= a_0 + a_1 P_j + \sum_{i=1}^{i} S_{ij} + \varepsilon_j;
\end{align}

and

\begin{align}
(16) \quad TCR_{misc} &= a_0 + a_1 \left( \sum_{j=1}^{3} TCR_j \right) + \varepsilon_{misc}.
\end{align}

The regression coefficients describe the marginal relationships between the dependent and the independent variables.

\textbf{Aggregation Problems}

Several potential problems can arise in the process of aggregating from the individual farm level to the entire state. As mentioned above, each farmer has differing expectations of price movements, thus they will not necessarily make the same marketing decision based upon the prevailing price at the time. Storage capacity also varies between farms. Some farmers may be forced to sell before they are ready, due to a lack of storage facilities, while their neighbor is not so restricted. Fixed repayment schedules for loans may also constrain the choice. All these factors contribute to marketing variability between farmers with the same information and crops, which can lead to inaccuracies due to aggregation.
The use of a price index can cause additional errors to creep into the analysis. A price index does not accurately reflect the movement of any one price, but some kind of average of all the prices in a group. This can cause the sample regression equations to misrepresent the true relationship between the dependent variables and the independent variables.

**Chapter Summary**

The importance of cash receipts in the generation of farm income is shown in this chapter. A hypothesized function relating cash receipts for each of the three major crop groups grown in South Dakota to their price index and available supply was constructed. Another function relating the miscellaneous receipts to the aggregate receipts from the three groups closed the system to determine cash receipts from all four groups of crops for the state. Presentation of the empirical results of the equations will be in the next chapter.
EMPIRICAL RESULTS

The equations were empirically fitted to annual data from 1956 through 1977. The adaptation of the models to fit the available data was discussed in the previous chapter. The following variables were used to fit the equations. All the data originated with the Economics, Statistics, and Cooperatives Service in Sioux Falls, South Dakota.

Data

Cash Receipts

Cash receipts data for the groups were compiled from data on cash income by commodities. Cash income relates to the value of the product sold off the farm. These data show the direct income from crops sold. Income from crops fed to livestock is included as part of livestock income. Cash income does not include agricultural conservation payments, price adjustment payments, agricultural production and practice payments, or disaster payments.

Price

The price indexes of local market prices received by farmers in South Dakota were used as the price variable for the first three commodity groups. Upon examination of the computational method used in compiling these indexes, it was apparent that this method had caused errors in the series. The price indexes were revised and updated for use in this model.
was shown above that the available supply comes from two separate sources; stock held from previous years, and new production. How these two elements combine is somewhat clouded by the timing factor. It was decided to specify available supply as the summation of January 1 farm stocks and the production for that year.

Any change in supply will be divided among its alternate uses. Thus it seems reasonable to assume the elasticity of cash receipts to supply with respect to any one commodity would range between zero and one. This assumption is a very tenuous one, however, and several factors may combine to subvert it.

Data Limitations

The first limitation is the use of a price index. An index is a method of aggregating which tends to misrepresent the true price of the individual commodities. Regressing an indexed variable will tend to misrepresent the actual relationships between the dependent variables and the independent variables.

The available supply variable is a simple summation of inventories and production. By using a summation, the actual available supply at any one time is overstated, either because the new production has not been harvested, some of the stocks have already been used, or both. This will cause the sample regression to misrepresent the actual relationships between the dependent and the independent variables.

Due to the large number of crops contained in the feed grains group, they could not all be considered in the statistical model. Corn and oats accounted for at least 70 per cent of the group's total
receipts for the entire sample period. It was decided to use them as indicative of the performance of the entire group.

Regression Results

The linearized equations were estimated using ordinary least squares. The results are examined for statistical and theoretical considerations.

Food Grains

Both logarithmic and actual values for price and supplies were regressed against logarithmic and actual values for cash receipts. The following estimates were obtained:

\[
\ln\text{CR}_{\text{fog}} = -8.018 + 1.491 \ln\text{P}_{\text{fog}} + 0.3741 \ln\text{S}_{\text{rye}} + 0.7889 \ln\text{S}_{\text{wheat}} \\
\text{(R}^2 = 0.9293, \text{S.E.} = 0.1759, \text{D.W.} = 1.92, \text{F} = 83.8787)
\]

If the regression error term is normally distributed with zero mean, it can be proved that the ordinary least squares regression will provide the best (most efficient) linear unbiased estimators of the true regression parameters. Estimators derived from the multiplicative form will in general exhibit some bias, but it is possible that they will have a lower standard error than the unbiased estimators. Since prediction is the stated objective, the estimators with low standard errors and some bias may be preferred to an unbiased estimator with higher standard errors.

The t-values for the regression coefficients are reported in parenthesis. All t-tests have been conducted under the hypothesis \(H_0: a_i = 0\) vs. \(H_1: a_i > 0\). F-, t-, and D.W.-tests cannot be used in the conventional sense on the multiplicative forms, since the error terms violate the classical assumption of normal distribution and zero mean. The statistics have been reported in the hope that they provide some measure of the fit of the regression.
The coefficients are all significant at the 5 per cent level. The F-values in both forms are significant with a p-value less than .01. The D.W. statistics fail to reject the null hypothesis of no serial correlation with a p-value less than .05.

The coefficients were positive meeting a priori economic considerations. The elasticity estimates for the logarithmic equation fall into the range expected. The marginal relationships in the linear equation, however, is somewhat suspect. The marginal contribution of rye is much higher than anticipated and may lead to some error when rye supplies vary considerably.

Feed Grains

Both logarithmic and actual values for price and supplies were regresses against logarithmic and actual values for cash receipts. The following estimates were obtained:

\[
(2) \quad \text{CR}_{\text{og}} = -185262 + 1318.28 \text{P} + 6.5117 \text{S}_{\text{rye}} + .8135 \text{S}_{\text{wheat}} \\
\quad \quad \quad \quad \quad (-5.59) \quad (9.80) ** \quad (2.09) * \quad (1.74) * \\
R^2 = .8662 \\
\text{S.E.} = 36798 \\
\text{D.W.} = 1.90 \\
F = 38.8504 \\
\]

*Denotes p-level < .05 
**Denotes p-level < .005 
***Denotes p-level < .001

\[
(3) \quad \ln \text{CR}_{\text{eg}} = -14.48 + 1.682 \ln \text{P} + .555 \ln \text{S}_{\text{eg}} + .9416 \ln \text{S}_{\text{oats}} \\
\quad \quad \quad \quad \quad (7.76) \quad (20.9) ** \quad (3.40) ** \quad (4.74) ** \\
R^2 = .9612 \\
\text{S.E.} = .1089 \\
\text{D.W.} = 2.23 \\
F = 160.591 \\
\]
The regression coefficients are significant at the .5 per cent level with one exception. The coefficient for oats supplies in the linear equation is significant at the 10 per cent level. The F-values are both significant at the one per cent level. The D.W. statistics fail to reject the null hypothesis at the 5 per cent level.

The coefficients are all positive meeting a priori economic considerations. Estimates of elasticity from the logarithmic equation fall in the anticipated range. The marginal contributions in the linear equation have no apparent discrepancies.

Oil Crops

Both logarithmic and actual values of price and supplies were regressed against logarithmic values for cash receipts. The initial estimation of the logarithmic form gave a constant term not statistically significant at the 25 per cent level. The equation was then reestimated without the constant term. The following estimates were obtained:

\[
\ln CR_{oil} = 0.802 \ln P_{oil} + 0.2709 \ln S_{flax} + 0.471 \ln S_{soybeans}
\]

\[
R^2 = 0.8986
\]
\[
S.E. = 26196
\]
\[
D.W. = 1.90
\]
\[
F = 53.1841
\]

*Denotes p-value < .1

**Denotes p-value < .005

***Denotes p-value < .001
\[ R^2 = .9599 \]
\[ S.E. = .0879 \]
\[ D.W. = 2.48 \]
\[ F = 294.987 \]

\[ (6) \quad \text{CR}_{\text{oil}} = -31623 + 288.525 \text{P}_{\text{oil}} + 2.6034 \text{S}_{\text{flax}} + 1.5326 \text{S}_{\text{soybeans}} \]

\[ R^2 = .9709 \]
\[ S.E. = 3417 \]
\[ D.W. = 1.30 \]
\[ F = 200.206 \]

*Denotes p-level < .001

The coefficients are all significant at the .1 percent level. The F-values are significant at the 1 percent level. The D.W. statistics are indeterminate in both cases, indicating some apparent correlation of the errors, but it is not clear as to the cause.

The regression coefficients are positive, meeting a priori economic considerations. The estimate of elasticity for the price variable is less than one, indicating perhaps that the sellers have elastic expectations of price for oil crops. The marginal contribution of price to cash receipts is also much lower than the two previous groups, but not necessarily inappropriate. The coefficients of the supply variables are in the expected range in both forms.

Miscellaneous

Both logarithmic and actual values for cash receipts of the above three groups were regressed against the logarithmic and actual values of the cash receipts for the miscellaneous group. Both equations exhibited the problem of positive first-order serial correlation. A commonly used correction procedure for this problem, the Cochrane-Orcutt Iterative Technique, would not provide valid results for the
multiplicative form of this equation. It was decided to correct the linear form and to use this equation for forecasting for both functional forms. The following corrected estimate was obtained:

\[
(7) \quad CR_{misc} = 40817.3 + 0.0132 \sum_{j=1}^{3} TCR_j
\]

\[
(2.01) (3.51) \quad S.E. = 1996.7
\]

\[
D.W. = 1.44 \quad F = 237.597 \quad \rho = 0.98103
\]

*Denotes p-level < .005

Little is apparent by examination of the regression coefficients. The corrected equation provides a good fit to the historical data, as evidenced by the higher $R^2$. Positive serial correlation is frequently due to the high correlation over time present in the cumulative effects of the omitted variables in the regression model. It is not surprising then that this equation would suffer from this problem, since the relation obviously does not specify all the variables which influence the miscellaneous group.

**Total Receipts**

The receipts block is closed by an identity summing the individual components. The following identity is used:

\[
(8) \quad CR_{total} = CR_{fog} + CR_{feg} + CR_{oil} + CR_{misc}
\]

**Comments**

The $R^2$ values for the seven equations ranged from .866 to .971, indicating a relatively close fit between the data and the regression equations. When taken separately without the miscellaneous equation common to both models, Model I and $R^2$ values ranging from .929 to .961, while Model II values ranged from .866 and .971. The individual
coefficients for Model I generally had lower p-values than Model II. It should be noted that neither of these two methods of comparison should be taken too seriously. A much more reliable source of comparison between equations will come with the full model forecasts and historical simulations in the following chapter.
Chapter 5

MODEL FORECASTS AND SIMULATIONS

The results of the previous chapter indicate that it is possible to obtain a reasonably good fit to the empirical data using the single equation regression model. The single equation results, however, do not guarantee the successful performance of the entire sector when the equations are solved together. There exists the possibility that the errors in each equation may combine in such a manner that the errors in equation (8) of the previous chapter will be unacceptable. On the other hand, the errors in the full models may be reduced in proportion to errors in the single equations. This chapter presents; (1) an explanation of the calculation of the forecasts, (2) the forecasts for 1978 and 1979, and (3) simulation tests of the models over the sample period.

Forecast Calculation

The principal purpose for the construction of these two models is for forecasting. By extrapolating our models beyond the period over which they were estimated, forecasts of the future movements of the dependent variables can be obtained, given information about the movements of the independent variables. The type of forecasts being estimated were point forecasts, that is, the prediction of a single number in each forecast period. This method was chosen over the interval forecasts, which consists of building confidence intervals around the point forecasts, because the intervals of the single equations do not
easily sum into the full models. In addition, the tests in the simula-
tions performed below give an indication of the range in which the
forecasts for the full model might lie.

Equations (1), (3), and (5) of Chapter 4 are in multiplicative
form. The data in these equations have been regressed in logarithms.
In forecasting from these equations, the logarithmic values for prices
and supplies were multiplied by their respective coefficients and
summed to obtain the forecast values of cash receipts in logarithms.
These estimates were then transformed back into original variables,
subject to some bias related to the conversion process. 7

Equations (2), (4), and (6) of Chapter 4 are the linear form
equations of the three major groups. The forecasts from these equa-
tions were obtained by inserting the exogenous values for price and
supplies into each equation.

Equation (7) of Chapter 4 is the linear form of the equation for
miscellaneous cash receipts. As discussed above, the serial correla-
tion in the original equation was corrected using the Cochrane-Orcutt
procedure. Forecasting with this equation involves first obtaining
the sum of the estimates of receipts from the three major groups to
be used as the independent variable. The forecasts were generated by
the following equation:

7The least squares estimates of the multiplicative form by the
method of logarithmic transformation lead to biased estimates of the
conditional population mean. The computed adjustment factors to be
multiplied by the forecast values were: (1) food grains = .84;
(2) feed grains = .88; and (3) oil crops = .91. For a more complete
discussion of the bias see Bolch and Huang [1].
\[
(1) \quad CR_{\text{misc}}^t = \rho (CR_{\text{misc}}^{t-1}) + a_0 (1-\rho) + a_1 \sum_{j=1}^{3} TCR_j^t - \rho \left( \sum_{j=1}^{3} TCR_j^{t-1} \right),
\]

where \( CR_{\text{misc}}^t \) = forecast for cash receipts, \( t \)th year;

\[ \rho = \text{first-order serial correlation coefficient.} \]

The forecasts from the full models follow from applying equation (8) of Chapter 4.

**Forecasts for 1978 and 1979**

The forecasts for the two years provide several different bits of information on the forecasting performance of the two models. For the year 1978, the exogenous variables, except for the miscellaneous group, was known with certainty. Also, the total cash receipts from crops were known, but not the receipts from the groups. Thus the full model forecast could be compared with reality, but the single equation forecasts could not. For 1979, all exogenous variables were unknown and none of the forecast can be compared. Since the exogenous variables were unknown for 1979, two price assumptions were used to generate forecasts. The exogenous variables used are presented in Table 2.

Table 3 presents the forecasts generated by the two models, along with preliminary estimates of total receipts for 1978 by another source. Both models apparently did very well in estimating total receipts in 1978. Model I had a forecast error of only 0.08 per cent, in dollar terms approximately $4,558,000. Model II did slightly poorer, with an error of 3.6 per cent or approximately $20,039,000.

Both models predicted another considerable increase for 1979. Under either price assumption, the estimated total crop receipts would
TABLE 2
EXOGENOUS VARIABLES UNDERLYING FORECASTS

<table>
<thead>
<tr>
<th></th>
<th>1978</th>
<th>1979</th>
<th>Assumption 1</th>
<th>Assumption 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Model I</td>
<td>Model II</td>
</tr>
<tr>
<td><strong>Food Grains</strong></td>
<td></td>
<td></td>
<td>S_{rye} \textsuperscript{a}</td>
<td>S_{wheat} \textsuperscript{a}</td>
</tr>
<tr>
<td></td>
<td>9,360</td>
<td>123,571</td>
<td>188</td>
<td>9,552</td>
</tr>
<tr>
<td><strong>Feed Grains</strong></td>
<td></td>
<td></td>
<td>S_{corn} \textsuperscript{a}</td>
<td>S_{oats} \textsuperscript{a}</td>
</tr>
<tr>
<td></td>
<td>252,704</td>
<td>199,344</td>
<td>169</td>
<td>313,146</td>
</tr>
<tr>
<td><strong>Oil Crops</strong></td>
<td></td>
<td></td>
<td>S_{flax} \textsuperscript{a}</td>
<td>S_{soybeans} \textsuperscript{a}</td>
</tr>
<tr>
<td></td>
<td>4,758</td>
<td>16,653</td>
<td>227</td>
<td>5,738</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td>531,209</td>
<td>546,527</td>
<td>712,546</td>
<td>692,950</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Units are in hundred thousand bushels.

\textsuperscript{b}Units are in hundred thousand dollars.
## TABLE 3

CASH RECEIPTS FORECASTS FOR 1978 and 1979  
(in hundreds of thousands of current dollars)

<table>
<thead>
<tr>
<th></th>
<th>1978</th>
<th>1979</th>
<th>1979</th>
<th>1979</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model I</td>
<td>Model II</td>
<td>ESCS(^a)</td>
<td>Model I</td>
</tr>
<tr>
<td>Food Grains</td>
<td>217,351</td>
<td>224,050</td>
<td>- - -</td>
<td>243,708</td>
</tr>
<tr>
<td>Feed Grains</td>
<td>246,043</td>
<td>250,697</td>
<td>- - -</td>
<td>345,189</td>
</tr>
<tr>
<td>Oil Crops</td>
<td>67,817</td>
<td>71,780</td>
<td>- - -</td>
<td>92,979</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>28,309</td>
<td>28,512</td>
<td>- - -</td>
<td>30,670</td>
</tr>
<tr>
<td>Total</td>
<td>559,558</td>
<td>575,039</td>
<td>555,000</td>
<td>712,546</td>
</tr>
</tbody>
</table>

\(^a\)Estimate provided by Economics, Statistics, and Cooperatives Service, Sioux Falls, South Dakota.
be between $116,850,000 and $188,887,000 above the 1978 level. This level of receipts would be the largest in history for the state except for the 1974 receipts. It might be noted that Model I is more sensitive to price changes as the two price assumptions led to a 7.4 percent difference in projections, while estimates from Model II were only 4.7 percent apart.

Simulations Over the Sample Period

It was noted in the introduction to this chapter that individually estimated equations, which fit the historical data very well, may combine to provide a simulation model of the entire system, which bears little resemblance to reality. The purpose of this section is to evaluate how the two models perform over the sample period for which all the equations were estimated, 1957 through 1977.8

Pindyck and Rubinfeld [12] mentioned several tests of ex post simulations which exist to show how closely the models estimates approach the true values for each year. One useful measure of how well the model tracks over the estimation period is given by the mean absolute per cent error defined by the following:

\[
(2) \quad \text{MAPE} = \frac{1}{T} \sum_{t=1}^{T} \left| \frac{Y_s^t - Y_a^t}{Y_a^t} \right|
\]

where MAPE = mean absolute per cent error;

---

8The Cochrane-Orcutt correction for serial correlation in the miscellaneous receipts equation resulted in the loss of the initial period's observation. Full model simulations could only be performed on the new sample period 1957-1977.
$Y^s_t =$ the simulated value of $Y$, $t^{th}$ year;

$Y^a_t =$ the actual value of $Y$, $t^{th}$ year;

$T =$ the number of periods.

One other test frequently used for evaluating simulation models is called the root mean square error. This differs from the MAPE in that it penalizes large individual error more heavily. The magnitude of this error can be evaluated only by comparing it with the size of the variable in question. This error test is defined as follows:

$$ (3) \text{RMSE} = \left[ \frac{1}{T} \sum_{t=1}^{T} (Y^s_t - Y^a_t)^2 \right]^{1/2}. $$

As is evident from Table 4, Model I fit the sample period better than Model II using both measures described above. The largest absolute error in Model I was 18.09 per cent, while Model II had one error of 30.54 per cent.

As mentioned earlier the simulation test can give some indication of the range in which the forecast of the entire model may lie. They give two measures of the errors which have occurred in the past and some indication of the range of errors to expect in the future.
<table>
<thead>
<tr>
<th>Year</th>
<th>Actual</th>
<th>Simulated</th>
<th>Error (%)</th>
<th>Simulated</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>147.1</td>
<td>147.0</td>
<td>-.07</td>
<td>145.4</td>
<td>-1.16</td>
</tr>
<tr>
<td>1958</td>
<td>195.5</td>
<td>184.5</td>
<td>-5.63</td>
<td>187.8</td>
<td>-3.94</td>
</tr>
<tr>
<td>1959</td>
<td>122.8</td>
<td>123.6</td>
<td>.65</td>
<td>85.3</td>
<td>-30.54</td>
</tr>
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<td>1960</td>
<td>153.3</td>
<td>144.4</td>
<td>-5.81</td>
<td>131.5</td>
<td>-14.22</td>
</tr>
<tr>
<td>1961</td>
<td>169.4</td>
<td>171.7</td>
<td>1.36</td>
<td>174.5</td>
<td>3.01</td>
</tr>
<tr>
<td>1962</td>
<td>169.3</td>
<td>179.0</td>
<td>5.73</td>
<td>192.4</td>
<td>13.64</td>
</tr>
<tr>
<td>1963</td>
<td>171.0</td>
<td>174.5</td>
<td>2.05</td>
<td>199.7</td>
<td>16.78</td>
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<tr>
<td>1964</td>
<td>150.4</td>
<td>154.4</td>
<td>2.66</td>
<td>146.2</td>
<td>-2.79</td>
</tr>
<tr>
<td>1965</td>
<td>158.8</td>
<td>171.2</td>
<td>7.81</td>
<td>150.5</td>
<td>-5.23</td>
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<tr>
<td>1966</td>
<td>198.9</td>
<td>197.6</td>
<td>-.65</td>
<td>193.5</td>
<td>-2.71</td>
</tr>
<tr>
<td>1967</td>
<td>203.9</td>
<td>217.9</td>
<td>6.87</td>
<td>216.4</td>
<td>6.13</td>
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<tr>
<td>1968</td>
<td>189.3</td>
<td>207.7</td>
<td>9.72</td>
<td>210.9</td>
<td>11.41</td>
</tr>
<tr>
<td>1969</td>
<td>196.1</td>
<td>213.5</td>
<td>8.87</td>
<td>238.2</td>
<td>21.47</td>
</tr>
<tr>
<td>1970</td>
<td>250.8</td>
<td>218.4</td>
<td>-12.92</td>
<td>233.3</td>
<td>-6.98</td>
</tr>
<tr>
<td>1971</td>
<td>229.1</td>
<td>249.4</td>
<td>8.86</td>
<td>286.7</td>
<td>25.14</td>
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<tr>
<td>1972</td>
<td>309.4</td>
<td>280.0</td>
<td>-9.50</td>
<td>324.9</td>
<td>5.01</td>
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<tr>
<td>1973</td>
<td>665.1</td>
<td>603.4</td>
<td>-9.28</td>
<td>562.7</td>
<td>-15.40</td>
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<tr>
<td>1974</td>
<td>835.0</td>
<td>813.7</td>
<td>-2.55</td>
<td>743.8</td>
<td>-10.92</td>
</tr>
<tr>
<td>1975</td>
<td>545.0</td>
<td>640.2</td>
<td>17.47</td>
<td>626.6</td>
<td>14.97</td>
</tr>
<tr>
<td>1976</td>
<td>380.6</td>
<td>389.4</td>
<td>2.31</td>
<td>494.0</td>
<td>29.80</td>
</tr>
<tr>
<td>1977</td>
<td>493.1</td>
<td>403.9</td>
<td>-18.09</td>
<td>397.4</td>
<td>-19.41</td>
</tr>
</tbody>
</table>

MAPE = 6.61
RMSE = 34.5

MAPE = 12.41
RMSE = 52.2
Chapter 6

RECOMMENDATIONS AND LIMITATIONS

The stated purpose of this study was first and foremost the construction of a forecasting model of aggregate crop receipts for South Dakota which had the potential of being extended to include all the component parts of farm income. The study focused on four parts: (1) to provide a framework upon which existing data could be utilized for the model, (2) to test the empirical performance of the model, (3) to provide forecasts for the current year, and (4) to lay the groundwork for future forecasting.

Recommendations

This research effort was carried out with the full knowledge that it was only the first step in the attempt to provide a mechanism for forecasting farm income. The construction of an econometric model of crop receipts sets a pattern for the eventual completion of the complete farm income model.

The directions that future research can take to build upon this meager start are basically twofold. The first direction would be a review of this study. One alternative would be a better specification of the marketing mechanism than was possible under the chosen framework. A related question is the problem of inventory changes which this study left exogenous. It was also considered that a combination of functional forms, for example using the linear oil crop equation with the other multiplicative equations, might forecast better.
The second direction is obvious to those versed in the components of net farm income. The following flowchart shows how the entire system might operate to generate these estimates. Not only does the composite model have great importance to the state economy, but each of the component parts will provide valuable information taken separately.

Limitations

Several limitations should be mentioned regarding the construction and application of these models.

The first major qualification of this study relates to the data used. All of the data used are statistical estimates rather than the summations of accurate accounting figures. This problem is multiplied by the use of price indexes with all the potential problems this can entail. It is impossible to determine the extent data errors are incorporated in the parameter estimates.

The second qualification relates to the aggregation of individual processes which is necessary to estimate on an aggregate basis. Some of the problems were mentioned in Chapter 3. Again, there is no way in knowing if a true relationship has been estimated between the variables or only a lucky accident in how the numbers were arranged.

A third qualification is that, if the above two problems are not too severe, the models reflect the historical pattern of how the sector has turned its produce into cash receipts. There is no guarantee that this pattern will remain constant in the future. Only continual
FIGURE 1

POSSIBLE SCHEMA OF FARM INCOME

Crop Receipts  Livestock Receipts  Subsidy Payments  Imputed Rent  Home Consumption

Money Income  Non-Money Income

Gross Farm Income

Production Expenses

Net Change Inventories

Net Farm Income
A fourth qualification relates to the problem mentioned earlier of the differing definitions of farm income. This study relates only to cash receipts and farm income as defined here. Any extension to other definitions cannot be guaranteed to provide reasonable results.

And finally, the statistical procedures used in estimating the models contain their own technical limitations which can be lost in the maze of impressive-looking computer print-outs. Thus, the model should be viewed as a complement, not a substitute, for information and judgement.
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