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A Dynamic Impact Model of Regional Income: A Reduced Form Approach

Cameron S. Thraen

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A DYNAMIC IMPACT MODEL OF REGIONAL INCOME:
A REDUCED FORM APPROACH

by

Cameron S. Thraen

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

1974
This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Thesis Adviser

Date

Head, Economics Department

Date
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Chapter 1

INTRODUCTION

In a time of increased awareness of regional and community repercussions of socio-economic and political decisions which often originate outside of the region or community, there is a strong need for the development of a theoretically acceptable, and statistically applicable method, by which the impact of these various decisions upon the regional economy can be delineated. A priori knowledge, based upon an abstract theoretical model is not sufficient. The ramifications of decisions which affect the income producing sectors of a regional economy are not contained within a vacuum. It is paramount that the regional impacts of such decisions be estimated before the policy implementation takes place.

This study explores the use of linear regression and reduced-form analysis\(^1\) as a method by which impacts of changing economic sectors on total regional income can be estimated. Analysis of this type will provide the regional economist and public policy makers with an improved basis for interpreting the nature of a regional economic system in the light of national, state, and regional decision implementation.

\(^1\)The specific properties and applications of this method will be examined in later chapters.
Problem

Of primary importance to the growth of a regional economy is the viability of its exporting sector. Economic growth depends upon a continuous marketing of products outside the region, stimulating consumption, investment and income of the region. This presumes that the region experiences a demand for the products it produces in excess of its own local demand; for in general the level of, or changes in local demand, will not be of the magnitude sufficient to support extensive growth of regional income.

The dependency of a regional economy upon its exporting sectors can be presented concisely in the light of economic theory. The export or economic base theory holds as its central hypothesis a functional relationship between the growth (stagnation) of local basic industries concerned primarily with product exportation and the growth (stagnation) of the local non-basic economy and, hence, total regional income. This functional relationship can be characterized as follows: Demand for the output of the exporting sectors is determined largely by external, i.e., exogenous, market forces. Changes in the exogenous demand factor result in changes in

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the export income and, via a multiple effect, result in changes in local nonbasic and total income in the region. Export sectors can be classified to include any sector which may exert an economic influence upon the region, yet is largely unaffected by the local economy itself. Thus, a causal chain is developed, linking the national economy to the local, via the intermediate export sectors.4

For example, assume that a region is characterized by the exportation of meat products. National demand for meat products increases (exogenous factor) and the output of the regional meat industry rises. Income originating within the meat export sector also rises. Additional income within the region is transmitted to the local economy in the form of higher wages and salaries, increased employment, and increased local purchases by the meat industry itself. The recipients of the additional income are now in a position to increase their consumption of locally produced goods and services—neglecting for now the influence of imports or other

4 Nourse, H. O., Regional Economics: A Study in the Structure and Growth of Regions. (New York: McGraw-Hill), 1968, pp. 192-192. This theoretical set of economic relationships postulates a positive influence, (e.g., increases (decreases) in the income originating in export sectors are related to increases (decreases) in specific aggregate regional variables) on personal income, wages and salaries, profits, etc., but that this may not necessarily hold for the relationship between the growth (decline) of export sectors and similar changes in sectors serving local demand only. If the capital and labor input markets are characterized by limited supply it may well be that particular sectors experience sustained growth at the expense of other regional sectors.
leakages. This spent income then becomes new income, only to be spent again. Continuous spending will eventually raise the level of income within the region by a multiple of the original increase in export income. An exogenous factor, i.e., increases in the national demand for meat products, has had a multiplied impact on the level of total regional income, via the meat exportation industry in that region.

Various methods have been developed by which the degree to which the export (basic), local (non-basic) and total income relationships hold may be tested and expressed in quantitative terms. This methodology spans a continuum from the descriptive and somewhat simplistic analysis of the economic base study approach to the other extreme of the very direct and complex analysis of the Leontiff, input-output technique.\(^5\) The economic base study\(^6\) approach attempts to delineate the economic ties of basic-nonbasic sectors through the use of analytically descriptive and quantitatively simple techniques. On the opposite extreme the Leontiff system requires the utmost in rigor and complex specification based on a sample of economic phenomena at a specific point in time.


It is the hypothesis of this study that linear regression and reduced-form analysis may offer a more workable alternative to regional impact analysis than either the economic base study or input-output analysis. It is not suggested that these latter methods are invalid nor that they are inappropriate as tools of economic research. What is suggested, is that given the dual criterion of precision and practical ease of implementation not beyond the grasp of those most concerned with regional impact analysis, i.e., regional economists and planners, the method employed herein may prove more suitable.

Purpose

The primary purpose of this study is to investigate the applicability of reduced form analysis as a method of estimating sectoral multipliers in regional economic analysis. It is also the purpose here to utilize reduced form analysis as a research tool in South Dakota economic analysis. The direct application of the method will focus on the Black Hills regional economy. A major percentage of regional economic problems stem from a continuously changing mix and location of economic activity combined with resource immobility (especially labor resources). Policies and programs which would encourage and stimulate new and/or existing economic activity to allow a fuller utilization of regional resources must be based upon a knowledge of the relative importance of existing economic sectors to overall regional development. Policies or programs which would
affect either directly or indirectly the performance of major regional economic activities may have significant ramifications for the overall economic well-being of the regional economy. The Black Hills regional economy is in a position of possibly being so impacted by policies and program decisions originating outside of the economic sphere. Recent involvement, both at the local and state level, concerning environmental and land use policies as well as regional planning programs in general may have long-run impacts on the primary production sectors of this economy. This research delineates these primary sectors, and their relative importance in determining total economic activity and estimates the impact coefficients associated with these. By providing estimates of the relative importance of each primary sector within the Black Hills region it is believed that decisions which would affect these sectors either now or in the future may be more properly evaluated before actual implementation.

Objectives

The general objective of this study was the specification of a method of delineating the primary sectors of a regional economy and their relative importance, applicable to regional policy formulation and evaluation. This requires the formulation of a sound theoretical and econometric base which allows the specification of primary sectors and estimation of impact coefficients. In addition, an analysis based on this econometric framework was performed to allow
insight into the process and direction of regional changes in the level of economic activity in the Black Hills region of South Dakota. The following specific components of this general objective are indicative of the direction and analysis of this study:

1. Development and exposition of theoretical concepts by which the general structure of a regional economy can be characterized.

2. Translation of the theoretical economic concepts into an econometric framework which is capable of being estimated given the current availability of secondary data.

3. Application of the conceptual econometric framework to empirical analysis with emphasis on providing a descriptive analysis and multiplier estimation for the Black Hills regional economy.

The attainment of these objectives provides a useful econometric framework from which the impact multipliers of a regional economy can be estimated with secondary data sources. The research also provides an enhanced view of the Black Hills regional economy for regional policy formulation and planning, both state and local, and generates a framework for further research.

The results of this investigation are presented in the following thesis format: Chapter 2 presents the basic economic theory upon which all of the succeeding analysis is built. In Chapter 3, this basic economic theory is translated into a theoretical economic model in order to provide the reader with the
necessary link between the abstractions of economic hypothesis and the concreteness of an econometric model. This extension of theory to mathematics is then summarized in Chapter 4. Here the econometric model which was used in the actual empirical analysis is presented equation by equation, along with the mathematical tools necessary to interpret the model once its parameters were estimated. Chapter 5 explores the data requirements specified by the model presented in Chapter 4. In Chapter 6, the presentation of actual empirical analysis of the selected study area is undertaken. Chapter 6 also contains a descriptive analysis of the study area. Chapter 7 presents the estimated parameters of the econometric model and their economic interpretation. Chapter 8 concludes the reporting of this investigation. The conclusions reached by the author, based on the results of the analysis as well as the limitations of such results and conclusions are presented. Areas of complementary research are also suggested.
Chapter 2

THEORETICAL ECONOMIC ANALYSIS

The impact resulting from the growth, decline or stagnation of primary sectors of an economy on total economic well-being has long been the concern of theoretical economists and policy makers. However most analysis of the past has been focused in terms of national variables. This focus has resulted in the implementation of economic analysis at a high level of empirical aggregation. It has been largely only in the last two decades that the development of theory has been focused on subsectors of the national economy and applied directly to regions in an attempt to provide a satisfactorily rigorous analysis of regional economic phenomena.


Of major reference here are the works of the economic theorists relating the economic growth phenomena to spatial distribution, location, etc. For example such works can be found in Regional Analysis, ed. by L. Needleman. (Maryland: Penquin Books, Inc.), 1968.
forth by each variant of regional analysis is the question of, "What is the basis for regional economic expansion?" Can a region undergo sustained economic development in the absence of an outside stimulus? If not, how important is the exogenous stimulus to regional growth or decline? Of those sectors directly linked to outside stimuli, i.e., export oriented sectors, which exhibit the largest relative influence upon the overall economic community? Assuming the dependency of the local economy on its exogenous counterpart, "How can the directions and magnitudes of sectoral changes and their attending regional impacts be adequately estimated?"

An economic theory which offers a basis for dealing adequately with these questions is that of the economic base or export base approach to regional analysis.

Export Base Theory

The export base theory postulates that regional dynamics can best be explained by focusing on changes in those sectors which produce primarily for export or to fulfill demand which is exogenous to the region. Fluctuations in regional income are due primarily to fluctuations in exports from that region to the rest of the world.

3The term "dynamic" as it appears throughout this study is defined so as to inform the reader that the economic relationships considered herein are fluid over time, as opposed to the concept of static or stationary relationships.
Regional income, i.e., total regional product adjusted for capital consumption allowances, in time \((t)\) is the sum of consumption expenditures, investment, government expenditures and the value of exports from that region adjusted for imports of raw materials used in production and consumption imports. In the short run the level of imports and consumption depend upon the level of regional income. Regional exports are assumed to be dependent upon the level of income in the rest of the world.

These basic relationships can be expressed diagramatically in the following manner:

**Figure 2.1**

**Figure 2.2**

[Diagrams showing regional income, factor utilization, regional spending, exports, imports, and net exports.]
The horizontal axis in Figures 2.1 and 2.2 measure regional income. The vertical axis of Figure 2.1 measures the level of regional spending, exports and imports. The vertical axis of Figure 2.2 depicts regional spending adjusted for exports and imports. The line (SS) in the Figure 2.1 exhibits the relationship between total regional expenditure—consumption, investment and government—and total regional income. The positive slope of (SS) indicates that higher levels of consumption spending are associated with higher levels of income. The line (MM) represents the positive relationship between levels of income and levels of import expenditures. The line (XX) indicates that exports from the region are independent of the level of income in the region and are therefore constant for each income level at any point in time. The vertical sum of expenditures (SS) and exports (XX) minus imports (MM) represents aggregate demand for the production of the region. This is represented in Figure 2.2 as the line (E'E').

In real terms the (OY') line in Figure 2.2 represents the aggregate supply curve of the region. The horizontal axis in Figure 2.2 measures not only income levels but also levels of resource utilization. The higher the level of income the higher the level of regional resource utilization. A point on (OY') depicts the level of factor income—consistent with given level of spending [C+I+G+(X-M)]—generated by the level of employment of resources as measured in dollars on the horizontal axis.
The (E'E') line shows the region's planned level of expenditure for differing income levels and resource use and (OY') shows the level of income generated in the region by production. If the level of income or resource use is below the point (OA) as measured on the horizontal axis (OA'), the level of planned expenditures (OD) exceeds the actual level of income (OA'). This results in a decrease in inventories below a level desired by the business community and production will increase to fulfill the excess demand. Increased production will then tend to increase employment and income, and the region will shift back toward the equilibrium level (OA). If the regional income level exceeds the point (OA), to (OF), desired inventories will be too high and production will be reduced. That is to say aggregate demand will be less than aggregate supply. Employment of resources would then decline and the level of income and resource use would approach the (OA) point of equilibrium. It is at this point that intended purchases are equal to actual purchases, i.e., the equilibrium level of income.

---

4 This argument assumes that the gap between desired expenditure (aggregate demand) and regional production (aggregate supply) is not totally filled by an increase in consumption imports. This is a totally realistic assumption in a closed economy. In an open economy—a relatively free flow of goods and services in and out of the region—it is possible that a portion of the excess demand will be filled by importation. However, the increase in demand may or may not be totally due to local factors. Whatever the cause it is highly probable that production within the region will respond to shrinking inventories and expand.
What is the impact on regional income if the level of regional exports rise thereby increasing desired spending? The line (XX) in Figure 2.1 will shift upward by the amount of the increase in exports. As the level of exports and the level of regional income is independent, this amounts to a parallel shift in (XX), as indicated by (CD) in Figure 2.3. This shift (CD) represents an increase in the demand for the region's products hence the (E'E') line shifts upward to (E"E''). The change from (E'E') to (E"E'') is by the same quantity at each regional income level. Given (E"E'') as the new expenditure line, regional income will tend toward the equilibrium.

Figure 2.3

![Graph showing the impact of increased exports on regional income](image_url)
point (OB) as in the previously cited example. The essential point here is not concerned with the ratio of income to exports but the relationship between the shift or change in exports and the attending impact on income within the region and resource utilization. In other words, our concern is not with \( \frac{\text{Income}}{\text{Exports}} \) but with \( \frac{\Delta \text{Income}}{\Delta \text{Exports}} \) \((\Delta = \text{change in})\).

The Theory of Multiplier Analysis

The analysis of the impact on regional income due to a shift in export output leads to the point of major interest. A rise in the level of exports will increase regional income by some multiple of the initial increase in export income. The magnitude of increase can be estimated for either a temporary or sustained increase in export income. Initially the increase in income will be equal to the increase in exports. This increase is an earned increase and is transmitted to the region via wages and salaries, interest and profits earned from the exporting sector. The inclusion of interest income and profits assumes that the regional economy is not totally devoid of local ownership of capital. The initial income rise is then translated into consumption spending by some proportion \((k)\) of the initial increase, the marginal propensity to consume \((\text{mpc})\). However, not all of the additional spending is transmitted to the local economy. There exist in the spending stream leakages. Some of the additional income is spent outside the region or for goods
and services that are produced outside the region, and some flows into savings which may or may not become local investment. Taxation also represents a leak from the system. The tendency to spend some income on imports is expressed as the marginal propensity to import (mpm). Then the mpc - mpm = marginal propensity to consume locally (mpcl). The magnitude of the mpcl determines the impact that an increase in export income will have on the regional economy. A numerical example may aid in clarification. Given that the mpc out of disposable income is 0.9 and the mpm is 0.3, then the mpcl is equal to 0.6. If the export sector increases production and disposable income by $100, the initial regional impact is also $100. Of this $100, [0.9 (mpc) x $100] or $90 will be spent. Not all of this will contribute to the local economy given that the mpm is equal to 0.3. The impact on the local economy will be based on mpc - mpm or 0.9 - 0.3 = 0.6. Thus the direct impact of $100 plus the indirect impact of $60 (0.6 x 100) = $160 will be felt by the local economy on the first round of spending. The total increase in spending can be expressed as the sum of an infinite geometric

5"Disposable" income is defined as that portion of gross income which is available for consumption after allowances are made for taxation.


7Assuming zero taxes, or that the tax payments on the initial $100 flow only to the regional coffers.
series, i.e., $dx + sdx + s^2dx + \cdots + s^ndx$ where $dx$ is the change in income from exports and $s$ is the mpc. The sum of this series is equal to $[(1/(1-s))] dx$. The term $1/(1-s)$ is the multiplier (impact coefficient) associated with the change in export income. In the example the value of the multiplier is $[1/(1-0.6)] = 2.5$. With the given assumptions, an increase in exports would result in a total increase in regional income by a factor of 2.5 times the initial export increase.

It is important to realize what the magnitude of the multiplier is dependent upon. It can be seen that the size of the multiplier is a function of (1) the magnitude of the mpc, (2) the magnitude of the mpm, or the tendency within the region to import consumption goods and services. It may be plausible to assume that the propensity of persons at the same income level to consume out of marginal income is approximately equal for all regions. The same conclusion is probably not applicable with respect to the marginal propensity to import. The mpm is highly dependent upon characteristics of the region, e.g., proximity to larger urban areas, etc., and the quantities and range of goods and services offered within the region itself.

---

8The sum of the geometric series is computed as follows:

1. $dy = dx + sdx + s^2dx + \cdots + s^ndx$
2. $sdy = sdx + s^2dx + \cdots + s^{n+1}dx$
Subtracting (1) from (2) yields
3. $dy - sdy = 1 - s^{n+1}$
4. $dy = 1 - s^{n+1}/(1-s)$; as $n$ becomes large and $0<s<1$, the term $(s^{n+1})$ approaches zero. Therefore (4) becomes
5. $dy = 1/(1-s)$; the multiplier.
The dependency of the regional impact multiplier on the region's propensity to import goods and services can be illustrated by example. In a relatively small region with an underdeveloped local service economy, the propensity to import may be high, i.e., mpm = 0.8. Assuming a constant mpc = 0.9 as before, the impact multiplier becomes $1/[1-(0.9-0.8)] = 1.11$. Very little beyond the initial increase generated from the exogenous export sector would be transmitted to the local economy. The major impact would be channeled outside the region to other areas. At the opposite extreme, a region with a very effective local economy, i.e., mpm = 0.1, would exhibit an impact multiplier of $1/[1-(0.9-0.1)] = 5$. Repeated rounds of local spending would generate an increase in local income five times the initial change in export induced income.

Before expressing the above theory as a simplified mathematical model, four important points must be recognized and elaborated upon. First, the above analysis assumes that the resources in the region in question are underemployed, i.e., have not reached full utilization. Thus any increase in exogenous demand for the products of the region would result in decreases in unused capacity and expansion of employment. If the region were at full capacity any

---

increase in exogenous demand without necessary increases in capital and labor would result in a bottleneck and regional inflation with no real gain.10

Second, although the multiplier is mainly thought of as reflecting positive impacts of the export sector on regional income, decreases in the export sector will have the same multiple negative impacts on local income. Third, exports are considered the prime regional mover only under the assumption that other things are constant. As can clearly be seen from the multiplier analysis, autonomous changes in such parameters as the mpc or mpm reflecting changes in tastes or spending patterns, could have similar effects on regional income. A lowering of the marginal propensity to import would result in more income, whatever the source, being spent at home. Fourth, the impact multiplier considered here may be an underestimate of the actual process. This is due to the lack of consideration of feedback effects from other regions. The portion of increased income from regional exportation which is channeled into imports becomes additional income for other regions. The resulting increase in extraregional income may further increase the demand for the region's exports thus causing the export function to shift upward again. Surely this is true of long run economic development. But, in the short run it need not be of the magnitude

to cause concern. A. J. Brown and Associates have estimated that for the United Kingdom the "multiplier is thus only marginally increased by putting in the effects of repercussions". 11

Simplified Mathematical Model of the Export Base Theory

The theoretical concepts of the export base and impact multiplier can be translated into a mathematical model which has the property of delineating the parameters of interest--impact coefficients--to this study more clearly. The income identity becomes:

\[(2.1) \quad Y = S + X - M\]

where

- \(Y\) = regional income
- \(S\) = investment, consumption and government expenditures
- \(X\) = exports from the region
- \(M\) = imports into the region

This identity states that regional income is equal to the sum of consumption, investment, government expenditures, and net exports--exports minus imports. The expenditure relationship is:

\[(2.2) \quad S = a + bY\]
\[(2.3) \quad M = c + eY\]
\[(2.4) \quad X = X\]

where

- \(b\) = marginal propensity to spend out of additional income
- \(e\) = marginal propensity to import out of additional income
- \(X\) = given level of exports.

---

By substitution of (2.2), (2.3), and (2.4) into the accounting identity (2.1), the solution for the equilibrium level of income can be found:

\[
(2.5) \quad Y = a + bY + \bar{X} - c - eY \\
Y = \frac{a + \bar{X} - c}{l - (b-e)}
\]

The change in \( Y \), regional income, with respect to a change in either \( a, c, \) or \( \bar{X} \) is equal to the multiplier \( l/[1-(b-e)] \). A change in \( \bar{X} \) is a change in exports from the region. Changes in the parameters \( (a) \) or \( (c) \) indicate shifts in expenditures or imports, respectively, resulting from changes in consumer habits or behavior. Thus, by changing \( (a) \) or \( (c) \) the entire functions (2.2) or (2.3) are shifted either upward or downward, leaving the slope of each function unchanged.

In the simplified model previously developed, \( \bar{X} \) represented the summation of individual export sectors for a given region. For example:

\[
\bar{X} = \sum_{i=1}^{n} x_i
\]

where:

\( \bar{X} = \) Aggregate Export Activity.

\( x_i = \) individual export sector activity.

The multiplier developed from this aggregation is then an average concept associated with changes in the aggregate export sector. The impact may be quite different from sector to sector due to differences in income flow of each sector in the total regional economy. Differences in sector impacts on regional income are not due to
differing spending patterns or habits associated with people employed in different sectors of the regional economy. Differences are hypothesized to exist because the distribution of income between wages and profits recipients and income class varies from sector to sector.

Assumptions

The theoretical model examined above relates changes in specific parameters, e.g., exports \( \bar{X} \), to changes or impacts on the level of income within a region. This is expressed in a highly aggregate sense with \( \bar{X} \) representing the sum of all changes in export income. What is of interest in this study is the relationship between changes in disaggregated \( \bar{X} \) and the impacts that the individual export sectors have on the income level of a region. It is hypothesized that changes in the individual export sector incomes will have varying impacts upon the income of a region and that the magnitudes of these impact multipliers are empirically estimatable. This results in the specification of \( m, \frac{1}{1-(b-e)} \) for each included local export sector.

The re-specification of the highly aggregate model into a disaggregate form requires the introduction of certain assumptions. In the aggregate model the assumption that the coefficients \( a \) and \( c \) are stable and constant over time is made. This is necessary in order to distinguish the impact of changing export income on total regional income from shifts in consumers purchasing behavior or tastes, that is changes in \( b \) and \( e \). This assumption introduces some
very serious criticisms of the theory as a long run explanation of regional growth. It is not probable that people's tastes, and spending behavior in general will remain constant over long periods of time. However, the theory when viewed as a short run analysis of intra-regional impacts is theoretically sound.\textsuperscript{12} Over a short time period behavior patterns can be assumed to be rather stable. Therefore, changes in the levels of regional income may be traced to changes in export income.

\textsuperscript{12}Nourse, op. cit., p. 163.
Chapter 3

ECONOMIC THEORY AND ECONOMETRIC MODELING

The theory underlying the concept of the export base and regional income determination is presented in Chapter 2. That presentation is general and rather simplified, but serves the purpose of providing a background upon which actual empirical analysis can be based. In general, to go from the theory to actual estimation of the parameters, the relevant economic relationships must be expressed as a consistent mathematical model. Real world phenomena must be expressed as concise functional equations. The grouping of these equations then becomes the model. This model of the economy is used to estimate the parameters of interest to the researcher, based on sample data generated by the particular economy under study. Before consideration of the actual econometric model, or set of equations used in this study, the basic ideas of structural equation and reduced-form equation are set forth in this chapter.

Economic Models

The functional relationships of an economic system are expressed mathematically in the form of structural equations. For example

\[
(3.1) \quad C_t = \alpha_0 + \alpha_1 (Y_t - T_t) + e_{1t}
\]
the consumption function. Consumption is some positive function of income minus taxes. The relation delineates the structure of the economic phenomenon of consumption. The parameter of this equation, \( a_1 \) is a structural parameter, and based on economic theory, may be specified as to sign and magnitude \text{a priori.} \[ 0 < a_1 < 1 \]

As discussed in Chapter 2, \( a_1 \) is the propensity to consume (mpc) out of additional disposable income. Each economic phenomenon which is to be structurally delineated can be expressed as a similar functional equation. For example, a simplified model can be presented by considering two other equations along with the consumption function, (3.1).

\[
(3.2) \quad I_t = \beta_0 + \beta_1 Y_{t-1} + \epsilon_{2t}
\]
\[
(3.3) \quad Y_t = C_t + I_t + G_t
\]

where (3.2) is the investment function and (3.3) is the income accounting equation. It should be noticed that (3.3) is not a functional form and is therefore not a behavioral equation but is an identity, equating current income to its components—Current Consumption, Investment and Government Expenditures. These three equations define the model. The stochastic terms \( \epsilon_{1t} \) of equation (3.1)-(3.2) specify that these structural equations are not deterministic in solution, but are subject to random disturbances.

The variables of an economic model are classified as \textit{endogenous} or \textit{exogenous}. Endogenous refers to variables which are affected by the economic system and may in turn influence the system themselves.
These variables may be expressed in either current or lagged form. Exogenous variables are defined as influencing the economic system but not being affected by it. These may also be current or lagged. This can be illustrated diagrammatically:

The exogenous, both current and lagged, and lagged endogenous variables are often referred to as predetermined variables. Classification of the variables in the illustrative model given above is:

- $C_t$, $I_t$ and $Y_t$ are current endogenous variables
- $T_t$ and $G_t$ are current exogenous variables
- and $Y_{t-1}$ is classified as a lagged endogenous variable.

Structural equations may contain both predetermined and current endogenous variables as explanatory factors. When an equation contains only predetermined variables, the parameters may be estimated directly by least squares regression. In the case when endogenous variables are included as explanatory factors direct estimation is not recommended.

As can be seen from the simple model presented above (equations 3.1-3.3), current consumption is a function of current income. A current endogenous variable is a function of another current

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endogenous variable. Income affects the level of consumption and
is also partly determined by that level of consumption. This is
referred to as a simultaneous structural relationship. Due to the
simultaneous nature of the model the parameters of the model are not
estimatable by the direct application of the least-squares regres-
sion analysis technique. Direct estimation of the parameters
would produce bias and inconsistent estimates of the true population
parameters.

By successive substitution of the equations of the model, the
system may be expressed in its reduced-form and the simultaneous
nature is eliminated. For example, consider the model presented
above. Substituting (3.2) and (3.3) into (3.1) gives

\[ C_t = \alpha_0 + \alpha_1 (C_t + B_1 Y_{t-1} + e_{1t} + G_t - T_t) + B_0 + e_{2t} \]

or

\[ C_t = \frac{\alpha_0}{1-\alpha_1} + \frac{\alpha_1 B_0}{1-\alpha_1} + \frac{\alpha_1 B_1}{1-\alpha_1} Y_{t-1} + \frac{\alpha_1}{1-\alpha_1} G_t - \frac{\alpha_1}{1-\alpha_1} T_t \]

\[ + \frac{\alpha_1 e_{1t}}{1-\alpha_1} + \frac{e_{2t}}{1-\alpha_1} \]

2The reader unfamiliar with regression analysis and least-
squares estimation is referred to Johnston, J., Econometric Methods,

3For an excellent exposition of the nature of the bias present
in directly estimated parameters of a simultaneous equation model,
see the article by Bennion, G. G., "The Cowles Commission Simultane-
and Statistics, Vol. 34, February 1952, 49-56. For a rigorous treat-
ment of the statistical nature of the problem of simultaneous equation
estimation, the original Cowles Commission Monograph No. 14, is
recommended, especially Chapter IV, "The Estimation of Simultaneous
Consumption is now expressed solely as a function of predetermined variables. The investment equation, (3.2), is already in the reduced form:

\[ I_t = B_0 + B_1 Y_{t-1} \]

Substituting (3.1) and (3.2) into (3.3) gives

\[ Y_t = \frac{\alpha_0}{1-\alpha_1} + \frac{B_0}{1-\alpha_1} Y_{t-1} + \frac{B_1}{1-\alpha_1} G_t - \frac{\alpha_1}{1-\alpha_1} T_t \]
\[ + \frac{\alpha_1 e_{1t}}{1-\alpha_1} + \frac{e_{2t}}{1-\alpha_1} \]

The reduced-form of the original structural model may now be expressed as:

\[ C_t = \pi_{10} + \pi_{11} Y_{t-1} + \pi_{12} G_t - \pi_{13} T_t + e_{1t} \]
\[ I_t = \pi_{20} + \pi_{21} Y_{t-1} + e_{2t} \]
\[ Y_t = \pi_{30} + \pi_{31} Y_{t-1} + \pi_{32} G_t - \pi_{33} T_t + e_{3t} \]

where \((\pi_{ij})\) are the reduced-form parameters.

The primary advantage of the reduced form model over the original structural model is that the reduced form parameters \((\pi_{ij})\) are estimatable by the direct application of ordinary least squares. These estimates will have the property of being consistent\(^4\) and unbiased and/or asymptotically efficient estimates.\(^5\)

---

\(^4\)"Consistent" in the statistical sense used here defines an estimate which approaches the true population parameter as the number of sample data points \((n)\) becomes increasingly larger.

Properties of the Reduced-form Coefficients

The reduced-form coefficients $\pi_{ij}$ also have another main advantage of special importance to this study. These coefficients are non-linear functions of the original structural parameters and may be interpreted as impact coefficients or multipliers associated with the economic system being modeled. Estimates of these parameters provide estimates of the multipliers developed theoretically in Chapter 2. Each coefficient of the set of reduced-form equations indicates the magnitude of the direct and indirect influence of some predetermined variable upon some current endogenous variable.

"In a linear model, a reduced form coefficient measures the change in the endogenous variable which occurs when a unit change occurs in the predetermined variable, with all other predetermined variables being held constant." Therefore the reduced form model affords the researcher the ability to estimate multipliers for a regional economic system by direct application of ordinary least squares regression analysis (OLS).

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6 Johnston, loc. cit.


8 The use of least squares as a means of quantitatively deriving estimates of the impact coefficients characteristic of an economy has been highly developed both theoretically and empirically. Many differing applications utilizing least squares have appeared in literature. See for example The Journal of Regional Science. This
journal has contained much of the current thought pertaining to regional economic analysis. Of these differing literary works concerning various aspects of multiplier estimation and regional analysis, the work of C. Brashler, "A Comparison of Least-Squares Estimation of Regional Employment Multipliers with Other Methods," Journal of Regional Science, Vol. 12, No. 3, 1972, pp. 457-468, and R. B. Billings, "The Mathematical Identity of the Multipliers derived from the Economic Base Model and the Input-Output Model," Journal of Regional Science, Vol. 9, No. 3, 1969, pp. 471-473, is of particular importance. Billings considers the relationship between least squares and input-output parameters from a mathematical viewpoint and concludes that the parameters are identical from the two models when "they are constructed with corresponding definitions and data." Brashler also examines the same relationship and concludes that the aggregate input-output technique is identical to the specification of a single equation model. He also concludes that the use of least squares appears to offer promise over the "more expensive formulations requiring primary data." The advantage of least squares over input-output is given as the ability to obtain comparable estimates of the economic parameters at decreased cost.
Chapter 4

A DYNAMIC ECONOMETRIC INCOME MODEL AND ITS INTERPRETATION

Having considered the relationship between structural and reduced form equations of an economic model, the parameters of each and the interpretation of the reduced form coefficients, we now turn to the development of a precise econometric model, its structural and reduced form. The simple model explored in Chapter 2 which presented the export base theory as a set of equations is extended in order to focus more directly on the estimation of reduced form multipliers.

The Structural Econometric Model

A regional economy can be expressed as a system of structural equations which link specific dependent (endogenous) variables to other endogenous, lagged endogenous and/or exogenous (current or lagged) variables. The structural model used in the study is a modification of a national model suggested by the work of Klein and Goldberger.1 The Klein-Goldberger model formulates the basic economic relations between income and expenditure in terms of

national variables while the modification used here allows a regional interpretation to be placed upon these same relationships. The modified model is then defined by the following structural equations:

\[ \begin{align*}
C_t &= \alpha_{10} + \alpha_{11} Y_t + \alpha_{12} K_{-1} + e_{1t} \\
I_t &= \alpha_{20} + \alpha_{21} K_t + \alpha_{22} K_{-1} + e_{2t} \\
W_t &= \alpha_{30} + \alpha_{31} Y_t + \alpha_{32} Y_{-1} + \alpha_{33} t + e_{3t} \\
Y_t &= C_t + I_t + Y_t + X_t \\
Y_t &= W_t + K_t \\
G_t &= G_t \\
X_t &= X_t \\
\end{align*} \]

where:

- \( C_t \) = regional consumption expenditures
- \( Y_t \) = regional personal income
- \( I_t \) = regional investment
- \( K_t \) = regional profits (personal returns to capital)
- \( W_t \) = regional wage and salary income
- \( G_t \) = total regional government expenditures
- \( X_t \) = total regional export income
- \( t \) = time trend

The endogenous variables of the model are \( C_t, Y_t, K_t, W_t, I_t \); while the exogenous or predetermined variables are \( Y_{-1}, K_{-1}, G_t, X_t, \) and \( t \).
Consumption Function:

Elementary economic theory tells us that consumption expenditures are some function of income, either current or past. Equation (4.1) specifies that current consumption is dependent upon the levels of current income and of lagged profits. Many functional forms of the consumption function have appeared in the economic literature and all are basically a derivative of simply specifying consumption as a function of income. The lagged profits variable is included in this equation because it is believed that consumption not only responds to the current level of income but also to the past performance of the economy as reflected in the level of profits. The difference between this formulation of the consumption function and that developed by Klein-Goldberger is that in (4.1) personal income $Y$ replaces the inclusion of two separate variables ($W_t$) and ($K_t$) in the Klein-Goldberger equation.

Investment Function:

The behavior of business investment within a regional economy is dependent upon the level of consumption ($C_t$), the interest rate and subjective expectation as to future profits. The dependency upon profits undoubtedly represents the prime motivation for regional investment. Equation (4.2) therefore expresses regional investment $I$ as a function of current and lagged profits, ($K_t$) and ($K_{-1}$). It is assumed that entrepreneurs expect future profits to be of the similar magnitude as current and past profits.
Wage and Salary Income Function:

The level of current wage and salary income within the region is a function of current and lagged regional income, \( (Y_t) \) and \( (Y_{t-1}) \). A time trend component \((t)\) is also included in this equation in order to reflect the rise in wage and salary income which is not directly linked to the growth in regional income.

Total Regional Income Identities:

Total regional income in time \((t)\) is equal to the sum of total expenditures within the region—i.e., consumption \((C)\), investment \((I)\), government expenditures \((G)\), and exports \((X)\)—and is expressed by the accounting relation \((4.4)\). This same relationship is expressed by \((4.5)\), where the sum of regional expenditures are given as their counterparts in the regional accounts. Thus regional income can also be expressed as the sum of wage income and profits in the region in any year \((t)\).

In this structural model the levels of government expenditures and exports are exogenous to the regional system. That is, these sectors' activities are assumed to be determined by factors outside the region. They can be entered autonomously into the economic relationships of the structural model. This model is not to be construed as an exhaustive functional interpretation of a regional economic system. On the contrary, the model is designed to emphasize only the basic relationships between consumer behavior, the levels of exogenously determined income and total regional
income. A more extensive model would consider an increased number of equations relating to more economic variables. The national model developed by Klein and Goldberger considers thirty-seven economic variables in twenty-one behavioral, technological, and definitional equations.² The added depth of a regional model paralleling that of the national Klein-Goldberger model would require regional data far beyond that presently available.

Reduced-Form Model

The structural model provides the basis upon which the reduced form model can be built. From the reduced form model estimates of the parameters relating the predetermined variables to the dependent economic variables can be derived. The structural model presented thus far is a system of equations, linear in all variables and simultaneous in nature. The parameters can not be uniquely determined nor is it necessarily desirable to do so. Unless the specific nature of the marginal propensities to consume, import, etc., are desired, the increased computational complexity required to derive these parameters need not be of concern. By expressing the dependent variables of the structural equations solely as functions of all the predetermined variables in the system, the model can be solved for its reduced form and estimates of the regional multi-

²Goldberger, op. cit., p. 15.
pliers derived. Thus equations (4.1) through (4.7) can be manipulated to yield the following reduced form model:

\begin{align}
Y_t &= \pi^{10} + \pi^{11} Y_{-1} + \pi^{12} K_{-1} + \pi^{13} G_t + \pi^{14} X_t + \pi^{15} t + e_{1t} \\
C_t &= \pi^{20} + \pi^{21} Y_{-1} + \pi^{22} K_{-1} + \pi^{23} G_t + \pi^{24} X_t + \pi^{25} t + e_{2t} \\
I_t &= \pi^{30} + \pi^{31} Y_{-1} + \pi^{32} K_{-1} + \pi^{33} G_t + \pi^{34} X_t + \pi^{35} t + e_{3t} \\
K_t &= \pi^{40} + \pi^{41} Y_{-1} + \pi^{42} K_{-1} + \pi^{43} G_t + \pi^{44} X_t + \pi^{45} t + e_{4t} \\
W_t &= \pi^{50} + \pi^{51} Y_{-1} + \pi^{52} K_{-1} + \pi^{53} G_t + \pi^{54} X_t + \pi^{55} t + e_{5t}
\end{align}

The parameters \((\pi^{ij})\) of each of the predetermined variables on the right hand side of equations (4.8) through (4.12) are "non-linear functions of the structural parameters and may be interpreted as the multipliers associated with increments in the various predetermined variables of the system."\(^3\)

It is interesting to note the specific properties of this reduced form model. By estimating the coefficients of the variables \((G), (X)\) and \((t)\), the multipliers of this system are determined. Thus for changes in any one of these variables the response in the endogenous variables will be given. The terms \((Y_{-1})\) and \((K_{-1})\) introduce a dynamic nature to each of the equations. Not only are the endogenous variables expressed as functions of purely exogenous

variables but also of past endogenous variables. This dynamic specification allows the estimation of the time path of the endogenous responses to be explored.

**Multiperiod Analysis of the Dynamic Reduced Form Model:**

Where the predetermined variables include lagged endogenous variables—so that the model is dynamic—knowledge of the time path of the exogenous variable can be utilized to generate the time path of the endogenous variables. The extension of the estimation of dynamic multipliers to time or period analysis is as follows:

Consider the reduced-form of the model:

\[(4.13) \quad y'(t) = x'(t) \Pi + \xi'(t)\]

where \(\Pi\) is the matrix of reduced form coefficients. Suppose there are \(K\) predetermined variables, \(M\) are endogenous variables lagged one period and the remaining \(K-M\) are exogenous. After partitioning and rearranging the reduced form may be expressed as:

\[(4.14) \quad y_t = Ay_{t-1} + Bz_t + \xi_t\]

where:

- \(y_t\) is \(M \times 1\) vector of current endogenous variables;
- \(y_{t-1}\) is \(M \times 1\) vector of endogenous variables lagged one period;
- \(z_t\) is the \((K-M) \times 1\) vector of exogenous variables;
- \(\xi_t\) is the \(M \times 1\) vector of reduced form disturbance;

---

A = is the M x M matrix of reduced form coefficients of \( Y_{t-1} \) (a sub-matrix of \( \Pi' \)) and,

B = is the M x (K-M) matrix of reduced form coefficients of \( Z_t \) (remaining submatrix of \( \Pi' \))

By lagging the equation (4.14) one period and substituting back in we have:

\[
y_t = A (A y_{t-2} + B z_{t-1} + \xi_{t-1}) + B z_t + \xi_t
\]

\[
= A^2 y_{t-2} + B z_t + AB z_{t-1} + \xi_t + A\xi_{t-1}
\]

Apply this procedure s times we find

\[
y_t = A^{s+1} y_{t-s-1} + \sum_{\tau=0}^{\infty} C_{s+1,t-\tau} + \sum_{\tau=0}^{\infty} A^\tau \xi_{t-\tau}
\]

where

\[
(4.17) \quad C_{s+1,t} = A^{s+1} B
\]

Letting s go to infinity, the final form of (4.16) becomes

\[
(4.18) \quad y_t = \sum_{\tau=0}^{\infty} C_{\tau,t-\tau} + \sum_{\tau=0}^{\infty} A^\tau \xi_{t-\tau}
\]

assuming that \( \lim_{\tau \to \infty} A^\tau = 0 \) --the impacts in successive years converge to zero and the system is stable. Extension of this to period analysis is quite easily seen. As \( C_0 = A^0 B = B \) are elements of \( \Pi' \) and are referred to as multipliers, in the same way, the elements of \( C_{\tau} = A^\tau B \) for (\( \tau < 0 \)) are multipliers. Elements of \( C_0 \) are referred to as the impact multipliers, i.e., each element gives a contemporaneous response to an exogenous variable. Elements of \( C_{\tau} \) (\( \tau > 0 \)) are the delay -- multiplier coefficients. Each element of \( C_{\tau} \) (\( \tau > 0 \)) gives the delayed response to an exogenous change in succeeding time periods.
The impact and delay multipliers give the response to a one-shot exogenous change -- i.e., investment expenditures rise by one unit in \((t)\) and then recede to their old level in \((t + 1)\). The initial increase will have a secondary effect in the initial period -- impact multiplier -- and then subsequent secondary (delayed) impacts in the succeeding time periods until \(\lim_{t \to \infty} A^T = 0\). The cumulative or total impact of the exogenous change is then the sum of the initial plus delayed impacts and may be expressed as:

\[
(4.19) \quad D_T = \sum_{\nu=0}^{T} C^\nu = \sum_{\nu=0}^{T} A^\nu B
\]

\[
= (I + A + \ldots + A^T) \cdot B; \quad (\tau = 1, \ldots)
\]

the elements of which give the cumulative response to an impulse or one shot change in an exogenous variable. The case of a sustained increase in an exogenous variable is easily handled by an extension of (4.19). A sustained increase in an exogenous variable can be seen as a continuous process of primary, initial and secondary responses. For example consider the following formulation of sustained impacts:
\[ \Delta \text{ in exogenous variable} \quad \text{Response in endogenous variable} \]

\[
\begin{array}{cccccc}
1 & 1 & 5 & 2.5 & 1.25 & .625 \\
2 & 1 & 5 & 2.5 & 1.25 & .625 & .3125 \\
3 & 1 & 5 & 2.5 & 1.25 & .625 & .3125 & .1562 \\
4 & 1 & 5 & 2.5 & 1.25 & .625 & .3125 & .1562 \\
5 & 1 & 5 & 2.5 & 1.25 & .625 & .3125 & .1562 \\
6 & 1 & 5 & 2.5 & 1.25 & .625 & .3125 & .1562 \\
\end{array}
\]

The aggregate response in any given time period is then the sum of the primary impact plus the secondary impacts operational in that year. This amounts to summing horizontally as opposed to diagonally for the cumulative response from an impulse change. This summation can be expressed as:

\[
\overline{D} = D_{\infty} = \sum_{\xi=0}^{\infty} A^\xi B = (I + A + A^2 + \ldots) \cdot B
\]

where: \( \overline{D} = (I - A)^{-1} B \).

\( \overline{D} \) is then referred to as the equilibrium long-run impact or response to a change in an exogenous variable. \( \overline{D} \) can be interpreted in two distinct ways: (1) the elements of \( \overline{D} \) give the cumulative response to a one shot change in an exogenous variable; (2) the elements of \( \overline{D} \) give the aggregate equilibrium response of the endogenous variables to a sustained change in an exogenous variable. The cumulative response from an impulse or one shot change or aggregate response from a sustained change can be expressed as:
(4.21) \[ D_\tau = (I - A^{\tau+1}) \bar{D} \]

using: \[ (I-A) \cdot (I + A + A^2 + \cdots + A^\tau) = (I-A^{\tau+1}) = (I + A + \cdots + A^\tau) \times (I - A) \]

thus the cumulative or aggregate response of the endogenous variables can be estimated by the use of equation (4.21).
(4.21) \[ D_{\tau} = (I - A^{\tau+1}) \overline{D} \]

using: \[ (I-A)(I + A + A^2 + \cdots + A^\tau) = (I-A^{\tau+1}) = \]

\[ (I + A + \cdots + A^\tau) \times (I - A) \]

thus the cumulative or aggregate response of the endogenous variables can be estimated by the use of equation (4.21).
Chapter 5

BASIC DATA REQUIREMENTS

The use of quantitatively descriptive methods of regional economic analysis is limited by the availability of the data base from which the researcher must necessarily function. Highly sophisticated techniques may exist, but if the cost of providing relevant data inputs greatly exceeds the quality of the outputs then those techniques are rendered useless from a practical view.

Data Sources

Basically there are two data sources from which researchers can work. The first is that of primary data collection by use of direct interviews, mail interviews, or surveys. The collection of data in this manner is extremely costly in terms of both money and time units. Due to the high cost, primary data generated for a specific project is usually limited in scope and is project peculiar. The necessity of this type of data generation for input-output analysis is the basic disadvantage which renders that technique of limited usefulness from a practical point of view.

The alternative to primary data is data from secondary sources, published and unpublished data and information sources that are generated by public and private data collection agencies. The main advantage of secondary data is that of time and money saved in not
having to generate the same data oneself. The major disadvantage is that these data may not be specifically applicable to the problem in question, may have to be altered in some fashion, or may serve only as a proxy for the actual measurement. Also the data, especially time series, may not be complete. Missing areas may have to be generated by the researcher. Despite these shortcomings of secondary data, the fact that they are available is an overriding criterion. The method of analysis utilized within this study is partially based upon such practical availability.

Data Development for Purpose of Analysis

The data used in conjunction with the reduced-form model developed in Chapter 3 were taken strictly from secondary sources with a few modifications or alterations. The secondary sources utilized are the series prepared by the Department of Commerce on a continuing basis at the county level. Specifically these are Personal Income and Components and Total Earnings by Broad Industrial Sector. Although the series are essentially complete for the time period 1965-1971, pre 1965 data are provided only at intervals beginning in 1929. The time series used extend from 1949 to 1970. Regression analysis was used to provide estimates for the missing data points between 1950 and 1965. In some cases and years, data were not reported because there were insufficient reporting firms within the specific sector. When this was encountered, missing data were estimated by using an average or percent of total method. The
central assumption was that each sector's percentage of the total earnings was roughly proportional to its percentage of total earnings the years directly bordering upon the missing year. The secondary data base was then adjusted to reflect real terms using the Consumer Price Index (CPI) on a 1967 base as a deflator. The rationale for using the CPI was that the major data explanatory component used in the analysis was total earnings, i.e., wages and salaries income, and that the inflationary trend of this variable is best measured by the CPI. This deflating was done in order to provide quantitative insights into the economic process in real changes over time, washing out the impact of inflationary trends. This adjustment enables the comparison of real personal income, total earnings, etc., in differing years over the 1950-1970 time series.

Export Data Estimation

The data base used to provide measures of the level of total earnings for the basic or export sectors was derived by two different regional analysis techniques. The first method, as suggested by Charles Tiebout\(^1\) is the "assumption" method. The very nature of the output of some economic sectors provides a substantial basis for classifying these sectors as predominantly export orientated. Thus the agricultural sector of a rural region may by assumption be

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considered a basic or export sector. It is highly unlikely that the production of the agriculture sector would be consumed locally and not exported outside of the region. Sectors which are engaged primarily in raw materials production can be similarly classified.

The second technique of estimating volume for particular economic sectors is that of location quotient analysis. This technique assumes that an industry's local non-export production is the same fraction of total regional production as total regional production in that industry is of total production of some benchmark economy, e.g., the national economy. Estimated export activity is then equal to total regional production in industry (i) minus the calculated non-export production of that industry. That is:

\[ A_{ei} = A_i - \left(\frac{U_i}{U}\right)A \]

where:

- \( A_{ei} \) = estimated export production of regional industry i.
- \( \left(\frac{U_i}{U}\right) \) = the ratio of the level of industry i production in the benchmark economy \( U_i \) to total benchmark production.
- \( A_i \) = total regional production in industry i.
- \( A \) = total regional production.

---


3 Notation borrowed from Greytak, loc. cit.
This technique of estimating the volume of exports for a particular economic sector rests upon the acceptance of some rather tenuous assumptions. First it is assumed that the marginal propensities to consume in the region and in the benchmark or base economy are equal. This may or may not be true. Second it is assumed that the products of the region and base economy are homogeneous in nature. This amounts to assuming that the physical make-up of the goods and services consumed in the region is the same as and proportional to the make-up in the base region. The third assumption is that local demand is fully satisfied before any products are exported.

In a statistical analysis of the technique of estimating export volume, Greytak,\textsuperscript{4} comparing observed data on export volume to that estimated, found that the location quotient method produced export estimates which were underestimations of the actual level. In short, the use of location quotient analysis results in a downward bias of estimates of exports. Because the use of this technique was confined to a single variable in this study, wholesale-retail and services exports, it was felt that exclusion of this sector would result in greater loss than would inclusion, as long as the limitations associated with the method and estimates are fully understood.

\textsuperscript{4}Greytak, loc cit. Greytak is extremely critical of the current methods used to estimate basic export activity of an industry within a region. His journal article is recommended reading.
Chapter 6

DESCRIPTIVE ANALYSIS OF THE BLACK HILLS REGION

The dynamic mechanism by which a regional economy either grows and develops or stagnates has been presented both theoretically and statistically. This is not enough. The bare bones of the theoretical econometric model must be, by practical necessity, fleshed out. Statistical development of the model provides the research analyst with estimated parameters of the economic system upon which useful inferences concerning future decisions and alternatives may be logically based. The model of the economic system considered theoretically in Chapters 2 and 3 and statistically in Chapter 4 was estimated by multiple regression. The results of that estimation are presented in Chapter 7. In order that the reader may gain a better grasp of the implications of the results presented in Chapter 7, the economic region to which the analysis has been applied is first analyzed from a descriptive standpoint. This consists of geographic description of the study area, followed by a brief exploration of specific economic properties of the region.

Descriptive Analysis of the Study Area

The study area chosen for research is the Black Hills region of South Dakota, as defined by the Business Research Bureau, University
The Black Hills region consists of six counties in Western South Dakota which exhibit certain physical and economic characteristics unique to the state. The boundaries of the region are given in Figure 6.1. The region is composed of six counties: (1) Butte, (2) Custer, (3) Fall River, (4) Lawrence, (5) Meade, and (6) Pennington.

Geographic Characteristics

The six counties comprising the study area make up a unique physical landscape within the state of South Dakota. The area is characterized by the Black Hills rock formation, which with forested hills and many lakes and streams is in striking contrast to the semi-arid, rolling landscape and flat plains which comprise the rest of the state. This uniqueness has been responsible for the Black Hills becoming the most predominant tourist attracting area within the state. The region has within its boundaries four National Parks -- Wind Cave National Park, Mount Rushmore, Badlands National Monument, Jewel Cave National Park -- and one state park, Custer State Park. The area is not completely made up of forested lands. Vast expanses of rolling grassland are located in the North, East and Southern portion of the region.

\[^{1}\text{South Dakota Economic and Business Abstract, Bulletin No. 107, May 1972, Business Research Bureau, School of Business, University of South Dakota, p. 1.}\]
Figure 6.1

Black Hills Region of South Dakota
By County

I. Butte
II. Custer
III. Fall River
IV. Lawrence
V. Meade
VI. Pennington
Population Characteristics

The population of the study area has become more urban with the passage of time. In 1950, 45.1 percent of the region's population were classified as urban dwellers. In 1960, those classed as urban had shifted to approximately 47.0 percent. By 1970 the urban percentage was 51.7 percent of the total population. Along with the rural to urban population shift, migration of people out of the area has been a predominant characteristic of the region. Migration patterns in the six county region are given in Table 6.1.

The net migration figure is not the difference between population in 1960 and 1970, but is calculated in such a manner as to take account of birth and death rates, natural increases and the level of expected population. As can be seen from Table 6.1, each county within the region, with the exception of Meade, has experienced significant out-migration of people. Meade County experienced an in-migration of 3,285 persons or 27.3 percent. This may be due to the location of Ellsworth Air Force base, within the county, and the rise in military activity of the Vietnam Era in the mid and late sixties. The migration pattern for the last three decades, 1940-1950-1960-1970, is presented in the last column of Table 6.1. Three of the six counties have experienced out-migration for the last three decades. Pennington county experienced out-migration for the first time in the 1960-1970 decade.
### TABLE 6.1

Migration Pattern  
Black Hills Region: By County  
1960-1970

<table>
<thead>
<tr>
<th>County</th>
<th>1960 Population</th>
<th>1970 Population</th>
<th>Net Migration</th>
<th>% Change</th>
<th>Migration Pattern(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butte</td>
<td>8,592</td>
<td>7,825</td>
<td>-1,506</td>
<td>-17.5%</td>
<td>0 - 0 - 0</td>
</tr>
<tr>
<td>Custer</td>
<td>4,906</td>
<td>4,698</td>
<td>-523</td>
<td>-10.7%</td>
<td>0 - 0 - 0</td>
</tr>
<tr>
<td>Fall River</td>
<td>10,688</td>
<td>7,505</td>
<td>-3,184</td>
<td>-31.9%</td>
<td>I - 0 - 0</td>
</tr>
<tr>
<td>Lawrence</td>
<td>17,075</td>
<td>17,453</td>
<td>-1,740</td>
<td>-10.2%</td>
<td>0 - 0 - 0</td>
</tr>
<tr>
<td>Meade</td>
<td>12,044</td>
<td>17,020</td>
<td>+3,285</td>
<td>+27.3%</td>
<td>I - 0 - I</td>
</tr>
<tr>
<td>Pennington</td>
<td>58,195</td>
<td>59,349</td>
<td>-12,154</td>
<td>-21.5%</td>
<td>I - I - 0</td>
</tr>
<tr>
<td><strong>Regional Total</strong></td>
<td><strong>111,500</strong></td>
<td><strong>113,850</strong></td>
<td><strong>-16,350</strong></td>
<td><strong>-14.7%</strong></td>
<td><strong>N/A</strong></td>
</tr>
</tbody>
</table>

\(^1\) 0 = out-migration; I = in-migration.

Source: South Dakota Economic and Business Abstract Bulletin No. 107, May, 1972, Business Research Bureau, School of Business, University of South Dakota.
In summary then, it can be seen that the study area has been experiencing a loss in total population, while those persons remaining within the region are shifting their location from rural to urban dwelling.

**Labor Characteristics**

A summary of the economic characteristics of the civilian labor force within the region is given in Table 6.2. As can be observed from Table 6.2 the Black Hills regional labor force can be characterized by a high percentage involvement of women and a significant percent of the over sixty-five population in the labor force. Manufacturing employment is approximately equal proportionately to that of the entire state, but is not a high percentage of the labor force. The six counties are very homogenous in the distribution of income, with the median level among counties of approximately $7,900.

**Economic Characteristics**

The economic characteristics of the study area are now presented from a general view. Detailed analysis of selected economic characteristics is presented later in this chapter.

By examining the personal income structure -- its major sources, distribution and trends -- of the counties within the Black Hills region, the researcher can gain an insight which may prove invaluable when drawing inferences from the impact analysis.
<table>
<thead>
<tr>
<th></th>
<th>Female 16 and Over %</th>
<th>Male 65 and Over %</th>
<th>Manufacturing Employment</th>
<th>Median Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>38.2</td>
<td>32.4</td>
<td>7.4</td>
<td>$7,494</td>
</tr>
<tr>
<td>Butte</td>
<td>40.8</td>
<td>36.2</td>
<td>5.0</td>
<td>7,937</td>
</tr>
<tr>
<td>Custer</td>
<td>36.4</td>
<td>37.4</td>
<td>10.6</td>
<td>7,589</td>
</tr>
<tr>
<td>Fall River</td>
<td>45.1</td>
<td>16.8</td>
<td>2.2</td>
<td>7,870</td>
</tr>
<tr>
<td>Lawrence</td>
<td>36.7</td>
<td>19.8</td>
<td>7.7</td>
<td>8,061</td>
</tr>
<tr>
<td>Meade</td>
<td>30.3</td>
<td>32.0</td>
<td>4.8</td>
<td>8,219</td>
</tr>
<tr>
<td>Pennington</td>
<td>43.3</td>
<td>29.8</td>
<td>10.2</td>
<td>8,281</td>
</tr>
<tr>
<td>Regional Average</td>
<td>38.7</td>
<td>28.6</td>
<td>6.7</td>
<td>7,937</td>
</tr>
</tbody>
</table>

Source: U.S. Census Reports, Bureau of the Census.
No analytical method provides complete knowledge. Inferences derived from a particular method take on valid meaning, only when considered in light of additional relevant information.

Table 6.3 presents personal income for the Black Hills region, for selected years. The data are adjusted for residence, reflecting the income structure within each county. The figures are presented in real dollars, therefore comparison between years and counties is possible. As is evident from Table 6.3, Pennington County dominates the personal income level of the region, contributing approximately 46 percent of total regional income in 1950 and 56 percent in 1969. The levels of personal income in 1965, 1966, and 1967 reflect a disrupting shock within the region's economy, concentrated primarily in Lawrence and Pennington Counties. As can be discerned from Figure 6.2, Personal Income within the Black Hills region had a strong growth from 1950-1962, declined slightly in real terms from 1962 to 1970. The Wage and Salary Disbursements component remained roughly stable around 200 million during the same period. The Personal Returns to Capital component declined slightly in this period.

The data presented above cover the broad areas of population, Labor and Personal Income Characteristics for the study area. From this broad overview, the reader should be able to get some idea of the structure of region under study. Specific descriptive analysis for those variables included in the impact analysis is now presented.
TABLE 6.3

Personal Income *
Black Hills Region: By County
Selected Years

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawrence</td>
<td>30.617</td>
<td>35.534</td>
<td>40.064</td>
<td>37.749</td>
<td>42.928</td>
<td>44.926</td>
<td>46.777</td>
</tr>
<tr>
<td>Pennington</td>
<td>87.697</td>
<td>154.092</td>
<td>180.692</td>
<td>178.776</td>
<td>165.870</td>
<td>173.480</td>
<td>174.993</td>
</tr>
<tr>
<td>Regional Total</td>
<td>187.460</td>
<td>268.426</td>
<td>302.406</td>
<td>303.188</td>
<td>292.127</td>
<td>306.287</td>
<td>314.860</td>
</tr>
<tr>
<td>State Total</td>
<td>1131.182</td>
<td>1117.656</td>
<td>1585.500</td>
<td>1690.127</td>
<td>1743.500</td>
<td>1808.640</td>
<td>1811.173</td>
</tr>
<tr>
<td>Regional as % of State</td>
<td>16.5</td>
<td>24.0</td>
<td>19.0</td>
<td>17.9</td>
<td>16.7</td>
<td>16.9</td>
<td>17.3</td>
</tr>
</tbody>
</table>

* Adjusted to 1967 Base.

Source: South Dakota Economic and Business Abstract Bulletin No. 107, May 1972, School of Business, University of South Dakota.
Figure 6.2

Personal Income
Black Hills Region, 1950-1970

Millions of Dollars

Personal Returns to Capital
(Proprietors Income + Property Income)

Wage and Salary Disbursements
+ Other Labor Income
Selected Economic Variables: Shift Share Analysis

The descriptive analysis which follows focuses primarily on those variables which appear explicitly in the reduced-form model presented in Chapter 4. The analysis involves consideration of total earnings data and shifts therein in the Black Hills Region during the period 1949-1970. Changes in the economic sectors of the study area are analysed via the technique of shift-share analysis. 2

Shift-Share Analysis

The technique of shift-share analysis differentiates two factors which relate to differences in the rates of growth between regions. This involves the comparison of the region's industrial mix and growth rates with those of a larger economic system or base, of which the region is a part. Mix refers to the composition of industrial sectors within the region. Shift-share analysis attempts to provide answers to two questions regarding the regional growth process. First, is the growth of the region as measured by its industrial mix rapid or slow? An industry is characterized at the regional level, as having either rapid or slow growth, by comparing its growth rate in the region with the growth rate of all

industries in the base economy. Therefore, an industry which grew faster than the overall rate for all industries within the base economy would be a rapid growth industry. The second question to which shift-share addresses itself is whether the region is increasing or decreasing its share of each of the industries? This question is resolved by comparing growth rates of particular regional industries with growth rates of the same type of industries at the aggregate economic base level.

By answering these questions, two types of effects which comprise shifts among regions can be delineated. The first of these are the mix effects which "... arise out of the fact that, system-wide, some employment sectors or industries expand more rapidly than others. As a consequence, those regions that tend to specialize in slow-growth sectors show net downward...shifts and vice-versa." The second effects delineated are the regional share effects in that "... some regions are expanding in certain employment sectors more rapidly than other regions. The regions that show net upward...shifts are those in which over-all access to basic inputs or markets have improved relative to other regions engaged in the same activity."  

4 Loc. cit.
The shift-share estimates presented here were calculated using a computer program \textit{SHARE} developed by the author.\textsuperscript{5} An excellent example of format and computations involved in a shift-share analysis are presented by Ashby.\textsuperscript{6}

Two important limitations of the shift-share technique should be noted. The emphasis of the method is in providing insights about the changing structure of a region by focusing on shifting patterns of specific economic indices. The impact of these changes is the subject matter of the reduced-form analysis and not shift-share analysis. Second, no cause and effect relationships are developed. Shift-share is a descriptive technique and any implications of cause or effect are reserved for other regional growth theories, e.g., export base theory.

With this brief description of the technique of shift-share analysis, the sectors of primary interest within the study area are presented. The analysis considers total earnings, as the central indicative variable. Total earnings is defined as the summation in each sector of wages and salary disbursements, other labor income, and proprietors income. The total earnings variable was chosen for several reasons. First employment may not adjust

\textsuperscript{5}The program was written and developed by the author and is available upon request from the Economics Department, South Dakota State University.

\textsuperscript{6}Ashby, op. cit., pp. 3-7.
fast enough to adequately reflect the changing income structure of the region. Second, we are interested in estimating income multipliers not employment multipliers. Third, total earnings as defined, more nearly approximates income originating within each sector in the region than other economic variables available, and therefore facilitates estimation of the attending impacts of sector changes within a region. This third point assumes that shifts, i.e., increases or decreases, in an economic sectors' share of output are rapidly reflected in the level of total earnings originating with that sector.

The regional variables which explain, at least hypothetically, the variation in personal income in the region are those which are considered to be primary or export sectors. For the Black Hills region this encompasses the agriculture, mining, tourism or whole-sale-retail trade and service exports and the federal, state and local government sectors. Taken as a unit, these five sectors are the predominant income producing sectors of the study area. The purpose of this study was to estimate the separate impact or multiplier coefficients for these five sectors. Before these estimates are presented, each of these sectors is discussed separately.

**Agriculture**

Agriculture in the Black Hills region can be characterized as an industry in which the income produced is being distributed among
fewer and fewer individuals. Table 6.4 presents changes in the number of farms in the region over the last three decades.

As can be seen from Table 6.4, all of the counties except Pennington within the region experienced significant declines in the number of farm units. The data in Table 6.5 indicate that as the number of farm units is decreasing, the average size of each unit has increased over the three decades.

The information of Table 6.5 is not surprising in light of the trend toward fewer farm units in the region. Two exceptions do exist though. First, Meade County experienced a decrease in the number of farm units from 1964 to 1969; i.e., 815 to 800 units, yet exhibits a decrease in average farm size in the same time period, 2,732 acres to 2,631. This indicates that as the number of farm units decreased, the amount of land classified as agricultural decreased faster. Second, Pennington County experienced the opposite phenomenon. The number of farm units increased slightly from 637 in 1964 to 700 in 1969, yet the average size of unit also increased from 1,759 in 1964 to 1,893 acres in 1969. This suggests that the amount of land in agricultural use was increased in this five year period.
### TABLE 6.4

Number of Farms
Black Hills Region: By County
Selected Years 1940-1969

<table>
<thead>
<tr>
<th>County</th>
<th>1940</th>
<th>1950</th>
<th>1959</th>
<th>1964</th>
<th>1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butte</td>
<td>800</td>
<td>668</td>
<td>583</td>
<td>546</td>
<td>508</td>
</tr>
<tr>
<td>Custer</td>
<td>554</td>
<td>469</td>
<td>355</td>
<td>305</td>
<td>N/A*</td>
</tr>
<tr>
<td>Fall River</td>
<td>587</td>
<td>451</td>
<td>399</td>
<td>383</td>
<td>327</td>
</tr>
<tr>
<td>Lawrence</td>
<td>469</td>
<td>389</td>
<td>301</td>
<td>257</td>
<td>263</td>
</tr>
<tr>
<td>Meade</td>
<td>1,365</td>
<td>1,060</td>
<td>857</td>
<td>815</td>
<td>800</td>
</tr>
<tr>
<td>Pennington</td>
<td>1,085</td>
<td>890</td>
<td>698</td>
<td>637</td>
<td>700</td>
</tr>
<tr>
<td>Regional Total</td>
<td>7,307</td>
<td>5,724</td>
<td>4,393</td>
<td>4,108</td>
<td>3,391</td>
</tr>
</tbody>
</table>

Source: Census of Agriculture and Annual Reports, South Dakota Crop and Livestock Reporting Service.

* N/A = not available.
TABLE 6.5
Average Size of Farms in Acres
Black Hills Region: By County
Selected Years, 1940-1969

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1950</th>
<th>1959</th>
<th>1964</th>
<th>1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butte</td>
<td>1,146</td>
<td>1,974</td>
<td>2,510</td>
<td>2,428</td>
<td>2,834</td>
</tr>
<tr>
<td>Custer</td>
<td>950</td>
<td>1,478</td>
<td>1,810</td>
<td>1,985</td>
<td>N/A*</td>
</tr>
<tr>
<td>Fall River</td>
<td>1,447</td>
<td>1,941</td>
<td>2,067</td>
<td>2,541</td>
<td>1,930</td>
</tr>
<tr>
<td>Lawrence</td>
<td>370</td>
<td>494</td>
<td>827</td>
<td>910</td>
<td>978</td>
</tr>
<tr>
<td>Meade</td>
<td>1,463</td>
<td>2,006</td>
<td>2,501</td>
<td>2,732</td>
<td>2,631</td>
</tr>
<tr>
<td>Pennington</td>
<td>930</td>
<td>1,176</td>
<td>1,516</td>
<td>1,759</td>
<td>1,893</td>
</tr>
<tr>
<td>Regional Average</td>
<td>1051.0</td>
<td>1511.5</td>
<td>1871.8</td>
<td>2059.0</td>
<td>2253.2</td>
</tr>
</tbody>
</table>

Source: Census of Agriculture and South Dakota Crop and Livestock Reporting Service.

* N/A = not available.
Interpretation of shift-share analysis\(^7\) for the Black Hills Region agricultural sector is presented in Table 6.6. The data utilized are total earnings by originating sector, adjusted to real terms and expressed in millions of dollars, (i.e., \$20.6 is \$20,600,000.00).

**Expected Change-Growth.** The total time period taken for the analysis is from 1949-1970 and is broken down to 21 specific changes, each one year in length. This allows the comparison of the regional agricultural sector growth rate with that of the national, all sector growth rate. Inspection of the expected growth column reveals that nationally all sectors grew annually at a rather steady pace, with declines occurring only in the 1957-1958 and 1968-1969 time periods. Comparison of these with the total (regional) change column reveals that the regional agricultural sector out-performed expected growth at the national rate, both in

\(^7\)The Agricultural shift-share table (and all other sector tables is interpreted in the following manner.

**Total Units I and II:**

This gives total regional agricultural earnings corresponding to the dates in the Years column.

**Expected Change:**

Total - this column reports the level of earnings of sector (i) at the end of the time period had that sector grown at the same rate as the base economy. In this analysis, the United States national economy is the economic base.
<table>
<thead>
<tr>
<th>Years</th>
<th>Total Units</th>
<th>Expected Change</th>
<th>Industry Mix</th>
<th>Regional Share</th>
<th>Total Change</th>
<th>Relative Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>Total - Growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49-50</td>
<td>19.58</td>
<td>24.42</td>
<td>20.75</td>
<td>1.17</td>
<td>-1.26</td>
<td>4.93</td>
</tr>
<tr>
<td>50-51</td>
<td>24.42</td>
<td>29.06</td>
<td>25.44</td>
<td>1.02</td>
<td>-0.10</td>
<td>3.72</td>
</tr>
<tr>
<td>51-52</td>
<td>29.06</td>
<td>27.38</td>
<td>29.44</td>
<td>0.38</td>
<td>-3.15</td>
<td>1.08</td>
</tr>
<tr>
<td>52-53</td>
<td>27.38</td>
<td>23.43</td>
<td>28.78</td>
<td>1.40</td>
<td>-6.01</td>
<td>0.67</td>
</tr>
<tr>
<td>53-54</td>
<td>23.43</td>
<td>22.73</td>
<td>24.73</td>
<td>1.30</td>
<td>-0.10</td>
<td>-1.90</td>
</tr>
<tr>
<td>54-55</td>
<td>22.73</td>
<td>21.63</td>
<td>24.18</td>
<td>1.45</td>
<td>-2.47</td>
<td>-0.07</td>
</tr>
<tr>
<td>55-56</td>
<td>21.63</td>
<td>22.64</td>
<td>22.80</td>
<td>1.17</td>
<td>-1.57</td>
<td>1.41</td>
</tr>
<tr>
<td>56-57</td>
<td>22.64</td>
<td>23.14</td>
<td>23.16</td>
<td>0.52</td>
<td>-1.15</td>
<td>1.13</td>
</tr>
<tr>
<td>57-58</td>
<td>23.14</td>
<td>29.04</td>
<td>23.03</td>
<td>-0.11</td>
<td>3.71</td>
<td>2.29</td>
</tr>
<tr>
<td>58-59</td>
<td>29.04</td>
<td>21.89</td>
<td>30.78</td>
<td>1.74</td>
<td>-5.91</td>
<td>-2.98</td>
</tr>
<tr>
<td>59-60</td>
<td>21.89</td>
<td>34.84</td>
<td>22.54</td>
<td>0.65</td>
<td>-0.84</td>
<td>13.13</td>
</tr>
<tr>
<td>60-61</td>
<td>34.84</td>
<td>31.84</td>
<td>35.23</td>
<td>0.39</td>
<td>2.07</td>
<td>-5.46</td>
</tr>
<tr>
<td>61-62</td>
<td>31.84</td>
<td>36.05</td>
<td>33.51</td>
<td>1.68</td>
<td>-1.60</td>
<td>4.14</td>
</tr>
<tr>
<td>62-63</td>
<td>36.05</td>
<td>34.08</td>
<td>37.42</td>
<td>1.36</td>
<td>-2.40</td>
<td>-0.94</td>
</tr>
<tr>
<td>63-64</td>
<td>34.08</td>
<td>7.01</td>
<td>35.59</td>
<td>1.51</td>
<td>-4.52</td>
<td>-24.06</td>
</tr>
<tr>
<td>64-65</td>
<td>7.01</td>
<td>13.98</td>
<td>7.44</td>
<td>0.43</td>
<td>0.96</td>
<td>5.58</td>
</tr>
<tr>
<td>65-66</td>
<td>13.98</td>
<td>16.79</td>
<td>15.04</td>
<td>1.06</td>
<td>-0.83</td>
<td>2.58</td>
</tr>
<tr>
<td>66-67</td>
<td>16.79</td>
<td>17.76</td>
<td>17.42</td>
<td>0.63</td>
<td>-2.56</td>
<td>2.90</td>
</tr>
<tr>
<td>67-68</td>
<td>17.76</td>
<td>19.86</td>
<td>19.38</td>
<td>1.62</td>
<td>-1.98</td>
<td>2.45</td>
</tr>
<tr>
<td>68-69</td>
<td>19.86</td>
<td>20.53</td>
<td>19.70</td>
<td>-0.16</td>
<td>1.20</td>
<td>-0.36</td>
</tr>
<tr>
<td>69-70</td>
<td>20.53</td>
<td>19.54</td>
<td>20.55</td>
<td>0.02</td>
<td>-1.86</td>
<td>0.85</td>
</tr>
</tbody>
</table>

1 Explanation of the column headings is given in footnote 7 of the text, page 64.

2 Total Units = Total Agricultural Earnings, U.S. Department of Commerce. Expressed in millions of 1967 dollars. Data for '51-'58, '60-'61 and '63 were estimated by the author.
increases and declines. The major decline occurred in the 1964–1965 time period, with regional agriculture experiencing an estimated 27.0 million dollar decrease in total earnings. Overall, the actual shifts vs. the expected shifts show a much higher degree of volatility, signifying perhaps the high degree of dependency on external factors and the precariously weak position of the agricultural sector in this region.

Growth - this column reports the changes that would have occurred in sector (i) earnings had this Black Hills regional sector grown at the same rate as the all sector earnings for the Nation.

Industry-Mix Effect:

The deviation of actual regional growth from national all sector growth is due to two primary factors. First, the sector considered on an aggregate national basis may be a rapid or slow growth sector relative to the national all sector growth rate. This is measured by the industry mix component. Positive components indicate that for the corresponding time period the sector of the economy under consideration grew more rapidly than the nation as a whole. Negative components have the opposite interpretation. The additional deviation of actual from national all sector growth is explained by the Regional Share effect.

Regional Share Effect:

This column reports the direction of change in the region's share of sector (i) earnings, relative to the national economic base. Positive regional share components indicate that over the time period utilized "...overall access to basic inputs or markets have improved relative to other regions engaging in the same activity", Smith, op. cit., p. 32.

Total Change:

This column reports the sum of the expected growth, industry mix and regional share columns and is equal to the actual regional change in the sector.
Industry Mix. The industry mix component for the Black Hills region's agricultural sector indicates that a significant proportion of the negative deviation of actual growth from the over-all national growth is due to the slow growth characteristic of the national agricultural sector. The predominantly negative industry mix values indicate that the agricultural sector on the national level grew slower than the national economy in 17 of the 21 time periods.

Regional Share. The regional share component in essence reflects shifts in the region's comparative advantage for each specific sector. The regional share column of agriculture reflects the competitiveness of the agricultural sector in the overall national sector was measured by total earnings in the industry. As can be seen the sector experienced significant positive shifts over grouped units of time, averaging 3-4 time periods. These positive shifts indicate an improvement in the relative national position of agriculture but, were offset to a degree by a few significant negative shifts, especially in the 1963-1964 period.

Summary. The agricultural sector: (1) exhibits much more volatility than would be expected given the National growth rate

Total Relative Change:

This factor reflects the amount by which the sector (i) either exceeded or fell short of the national over-all growth. For example a positive component→3.50→would indicate that the particular sector (i) exceeded that level of earnings, employment, etc., which it would have attained had it grown at the same rate as the national average, by 3.50 units. The relative change component is the sum of the industry mix and regional share components.
for all industry, (2) is characterized as a slow growth sector, and (3) is experiencing a net positive shift in its position relative to other regions engaged in the same activity.

**Mining**

The Black Hills region is unique, especially in its endowment of mineral resources. Located in Lawrence County is the United States' leading gold producing mine. Recent international monetary decisions, which have permitted the raising of the price of gold could conceivably have a significant impact on the Black Hills regional economy. The Black Hills region also produces large quantities of sand and gravel and of granite, South Dakota's third most important mineral product. The importance of mineral production to the Black Hills region can be seen from Table 6.7. Lawrence County's mineral production as a percent of total state value equaled 42+ percent in 1968 and 44 percent in 1969, while Pennington County produced an additional 15+ percent and 20 percent in 1968 and 1969, respectively.

Results of the shift-share analysis of the Black Hills regional mining sector are presented in Table 6.8. The data utilized are total earnings by originators sector, adjusted to real terms and expressed in millions of dollars.

**Expected Change-Growth.** Inspection of the expected change-growth column indicates that, had the region's mining sector grown at the same rate as all sectors for the nation, it would have
TABLE 6.7  
Value of Mineral Production  
Black Hills Region: By County  
Selected Years, 1967-1968 ($000)

<table>
<thead>
<tr>
<th></th>
<th>1968</th>
<th>1969</th>
</tr>
</thead>
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<tr>
<td>Butte</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>Custer</td>
<td>672</td>
<td>437</td>
</tr>
<tr>
<td>Fall River</td>
<td>W</td>
<td>W</td>
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<tr>
<td>Lawrence</td>
<td>22,348</td>
<td>23,725</td>
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<tr>
<td>Meade</td>
<td>287</td>
<td>369</td>
</tr>
<tr>
<td>Pennington</td>
<td>8,150</td>
<td>10,625</td>
</tr>
<tr>
<td>Regional Total(^1)</td>
<td>31,457</td>
<td>35,156</td>
</tr>
<tr>
<td>State Total</td>
<td>52,618</td>
<td>54,086</td>
</tr>
<tr>
<td>Regional as % of State Total</td>
<td>59.7%</td>
<td>65.0%</td>
</tr>
</tbody>
</table>

W indicates data withheld to avoid disclosure of reporting firm.
\(^1\)Regional totals are reported only for those counties reporting individually.

Source: South Dakota Economic and Business Abstract, Business Research Bureau, School of Business, University of South Dakota.
### TABLE 6.8

**Mining Shift-Share Analysis**

1949-1970

<table>
<thead>
<tr>
<th>Years</th>
<th>Total Units</th>
<th>Expected Change</th>
<th>Industry Mix</th>
<th>Regional Share</th>
<th>Total Change</th>
<th>Relative Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>Total - Growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49-50</td>
<td>9.55</td>
<td>10.07</td>
<td>10.12</td>
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<td>0.72</td>
<td>-0.77</td>
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</tr>
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<td>0.16</td>
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<tr>
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<td>11.57</td>
<td>11.80</td>
<td>0.62</td>
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<td>0.33</td>
</tr>
<tr>
<td>54-55</td>
<td>11.57</td>
<td>12.59</td>
<td>12.31</td>
<td>0.74</td>
<td>-0.64</td>
<td>0.92</td>
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<td>12.59</td>
<td>12.31</td>
<td>13.27</td>
<td>0.68</td>
<td>0.06</td>
<td>-0.24</td>
</tr>
<tr>
<td>56-57</td>
<td>13.09</td>
<td>12.81</td>
<td>13.39</td>
<td>0.30</td>
<td>-1.18</td>
<td>0.60</td>
</tr>
<tr>
<td>57-58</td>
<td>12.81</td>
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<td>-0.06</td>
<td>-0.68</td>
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<td>14.05</td>
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<td>-0.72</td>
<td>1.46</td>
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<td>13.43</td>
<td>14.47</td>
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<td>-0.99</td>
</tr>
<tr>
<td>60-61</td>
<td>13.43</td>
<td>13.65</td>
<td>13.58</td>
<td>0.15</td>
<td>-1.11</td>
<td>1.19</td>
</tr>
<tr>
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<td>13.98</td>
<td>14.37</td>
<td>0.72</td>
<td>-0.86</td>
<td>0.47</td>
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<tr>
<td>62-63</td>
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<td>14.51</td>
<td>0.53</td>
<td>-0.50</td>
<td>0.30</td>
</tr>
<tr>
<td>63-64</td>
<td>14.31</td>
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<td>14.95</td>
<td>0.63</td>
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<td>-0.12</td>
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<tr>
<td>67-68</td>
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<td>1.21</td>
<td>-1.33</td>
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<td>68-69</td>
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<td>69-70</td>
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<td>14.95</td>
<td>16.41</td>
<td>0.01</td>
<td>0.22</td>
<td>-1.68</td>
</tr>
</tbody>
</table>

1 Explanation of the column headings is given in footnote 7 of the text, page 64.

2 Total Units = Total Agricultural Earnings By County, U.S. Department of Commerce. Expressed in millions of 1967 dollars. Data for '51-'58, '60-'61 and '63 were estimated by the author.
exhibited a net positive, stable growth pattern over the twenty-one year period. Comparison of this with the total change column, i.e., actual annual changes, reveals that this sector experienced an actual growth pattern very much like that expected.

**Industry Mix.** The Industry Mix component of the analysis shows a significant net downward shift, with positive shifts in only five of the twenty-one time periods. This is evidence of the nature of the sector's national growth rate. The negative shifting over time indicates that the national average rate of growth for all sectors was higher than for that of the national mining sector.

**Regional Share.** Inspection of the regional share column indicates that the Black Hills Region Mining sector enjoyed favorable shifts relative to other regions engaging in this activity up until the start of the 1963-1964 time period. This is evidenced by the positive net shifts from 1949 to 1962 and the following negative net shifts from 1963 to 1970.

**Summary.** The mining sector of the study region, as measured by total earnings data: (1) has experienced a stable growth comparable to that of the nation as a whole, (2) is a slow growth industry, and (3) seems to be losing a portion of its regional comparative advantage. A short word may be useful in regard to the third point. The time period of this negative regional share component coincides very closely with the time period in which the
Homestake Gold Mine began to experience difficulties on the labor and environmental fronts which may result in a lowering of output.

**Wholesale-Retail Trade and Services**

Various studies as to the extent of the tourism sector have been completed in South Dakota. However, although these studies have provided invaluable data as to the dollar magnitude of the tourist industry in the state, they provide little information on specific regions within the state.

In considering the economy of the Black Hills region, the magnitude of the earnings derived from tourism is felt to be of special importance. The unique geographic features of the Black Hills region make this area the leading tourist attraction within the state of South Dakota. For this reason and because of a lack of direct regional tourism data, a proxy for tourism earnings was needed. This required that some measure of export volume for those sectors most widely influenced by tourist expenditures -- wholesale-retail trade and services -- be estimated by the use of the location quotient technique discussed earlier in Chapter 5, page 45.

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9 Notable among these are studies by the Business Research Bureau, School of Business, University of South Dakota, completed under the direction of V. E. Montgomery.
The reader is cautioned to interpret these data as being only estimates, possibly crude at that, of export volume of the wholesale-retail trade and services sector. It was felt that exclusion of the tourism earnings variable from the impact analysis would entail more serious harm or misspecification than inclusion of an estimate of the actual data, as long as the limitations and shortcomings of this estimation are made explicit. The specific estimates of the export volume of these sectors was accomplished by applying location quotient analysis to the separate sectors of wholesale-retail trade and service, and summing across these for each year. The shift-share analysis of each sector is followed by presentation of the estimated export volume for these sectors.

### Wholesale-Retail Trade

Shift-share analysis results for the Black Hills region's wholesale-retail trade sector are presented in Table 6.9. The data utilized are total earnings by originating sector, adjusted to real terms and expressed in millions of dollars.

**Expected Change-Growth.** Inspection of the expected change-growth column indicates that had the regional sector grown at the same annual rate as the nation as a whole, it would have exhibited net positive growth in excess of one million dollars in annual earnings. Comparison of the expected annual changes with those that actually occurred in the region indicates that on the average,
<table>
<thead>
<tr>
<th>Years</th>
<th>Total Units</th>
<th>Expected Change</th>
<th>Industry Mix</th>
<th>Regional Share</th>
<th>Total Change</th>
<th>Relative Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>Total - Growth</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>49-50</td>
<td>25.26</td>
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<td>36.40</td>
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<td>41.76</td>
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<td>-0.93</td>
</tr>
</tbody>
</table>

1 Explanation of the column headings is given in footnote 7 of the text, page 64.

2 Total Units = Total Agricultural Earnings By County, U.S. Department of Commerce. Expressed in millions of 1967 dollars. Data for '51-'58, '60-'61 and '63 were estimated by the author.
the regional wholesale-retail trade sector experienced about the same overall net positive growth path as was expected.

Industry Mix. Examination of the Industry Mix column indicates that the wholesale-retail trade sector, as a national industry, tended to experience rapid and slow growth in a cyclical fashion. In ten of the 21 periods, the shift was negative, with the remaining 11 being in the positive direction. The overall net shift of the Industry Mix component indicates that the industry could be characterized as a slightly faster growth industry than the nation as a whole.

Regional Share. Inspection of the Black Hills region wholesale-retail trade sector regional share component tends to offer evidence contrary to that often suggested for this region's wholesale-retail trade sector. If the demand or flow of tourist dollars is reflected in shifts in the earnings of this sector (which it is believed to be), then the data in the regional share column suggest that this sector in the study area is losing economic position relative to other regions.

Summary. The wholesale-retail trade sector in the study area: (1) is experiencing an annual growth pattern comparable to the nation's growth rate, (2) appears to have a cyclical pattern in its overall growth rate, and (3) is in a state of decline relative to other sectors in other regions.
Service Sector

Shift-share analysis of the service sector for the Black Hills region is presented in Table 6.10. The data utilized are total earnings by originating sector, adjusted to real terms and expressed in millions of dollars.

Expected Change-Growth. The growth pattern of the services sector reflected in the expected change-growth column indicates that the regional service sector would have experienced a positive growth path, gaining in annual magnitude after 1961, had it grown at the same rate as the nation as a whole. Comparison with the actual total change column indicates that the service sector in the study region also experienced a growth pattern which was net upward, but with slightly more volatility than the expected path.

Industry Mix. The Industry Mix column indicates that the services industry on the national level had an overall growth rate which exceeded the national growth rate. An interesting note is the apparent cycle which the column exhibits. From the 1953-1954 period, the sector grew at less than the national overall rate every third time period until 1962-1963, after which the cycle lengthened to five periods, and then receded to two periods.

Regional Share. Inspection of the regional share column indicates that the region's service sector also lost ground relative
### TABLE 6.10

**Services**

**Shift-Share Analysis**

1949-1970

<table>
<thead>
<tr>
<th>Years</th>
<th>Total Units&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Expected Change</th>
<th>Industry</th>
<th>Regional</th>
<th>Total</th>
<th>Relative</th>
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<tr>
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<td></td>
<td>Total - Growth</td>
<td>Mix</td>
<td>Share</td>
<td>Change</td>
<td>Change</td>
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<td>1.10</td>
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<td>17.88 0.94</td>
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</tr>
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<td>-0.02</td>
<td>1.61</td>
<td>+0.46</td>
</tr>
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<td>0.60</td>
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<td>0.59</td>
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<td>0.32</td>
<td>-0.99</td>
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<td>3.65</td>
<td>1.81</td>
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</tr>
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<td>-2.55</td>
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<td>-0.09</td>
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<td>1.23</td>
<td>+1.20</td>
</tr>
</tbody>
</table>

1. Explanation of the column headings is given in footnote 7 of the text, page 64.

2. Total Units = Total Agricultural Earnings By County, U.S. Department of Commerce. Expressed in millions of 1967 dollars. Data for '51-'58, '60-'61 and '63 were estimated by the author.
to service sector activity in other regions. This is especially apparent from the net negative shift of the 1962-1969 time periods.

**Estimated Export Volume**

As discussed previously, the inclusion of the wholesale-retail and service sectors into the impact analysis required the estimation of a proxy variable for the quantity of earnings in these sectors attributable to export activity. The estimated data are presented for wholesale, retail and service sectors, in Table 6.11. Also included in this table are the estimated location quotients for each year.

A location quotient equal to 1 indicates that the particular sectors earnings as a percentage of the regions total earnings is equal to the same sectors national earnings as a percentage of total national earnings. For example:

\[ LQ_{ij} = \frac{b_{ij}}{b_{oij}} \]

where:

- \( LQ_{ij} \) = estimated location quotient for sector (i) region (j).
- \( b_{ij} \) = total earnings of sector (i), region (j).
- \( b_{oij} \) = total earnings of region (j).
- \( b_{io} \) = total earnings of sector (i) of the base economy.
- \( b_{oo} \) = total earnings of the base economy.

A location quotient which exceeds 1 indicates that the sector is specialized relative to the base economy and produces in excess of
TABLE 6.11

Estimated Location Quotients and Export Volume for Wholesale-Retail Trade and Service Sectors for the Black Hills Region: 1949-1970

<table>
<thead>
<tr>
<th>Year</th>
<th>Location Quotient</th>
<th>Export</th>
<th>Volume**</th>
</tr>
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<td>Wholesale-Retail Trade</td>
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<td>WRT</td>
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</tr>
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<td>2.98</td>
<td>18.09</td>
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<td>1955</td>
<td>2.46</td>
<td>2.84</td>
<td>18.93</td>
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<td>1959</td>
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<td>1969</td>
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<td>2.58</td>
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<tr>
<td>1970</td>
<td>2.46</td>
<td>2.74</td>
<td>23.49</td>
</tr>
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</table>

* A location quotient is a ratio of the relative magnitude of a sector's earnings within a region to the relative magnitude of sector earnings nationally.

** Export volume is in real dollars, expressed as millions.
its local demand, thus engaging in exporting. A value which is less than one indicates that the sector is not sufficiently large relative to the region to adequately supply the region's local demand, thus the region imports a proportion of the products of that sector.

Given the unique features of the Black Hills region and the assumed predominance of tourist trade in the area, location quotients for the wholesale-retail trade and services sectors would be expected to exceed 1. That this is in fact the situation can be demonstrated with data from Table 6.11. Estimates for the state of South Dakota have placed the value of the location quotient for these same sectors at 1.2-1.3. The values for the Black Hills region are well above this range, being 3.10 and 3.15 in 1949 for wholesale-retail trade and services, respectively. Both sectors have lost some ground by 1970, their respective location quotients being 2.46 and 2.74 in that year. This indicates that these sectors are not as predominant in fulfilling outside demand in 1970 as in 1949. However, the magnitude of these values remains above that of the state and the minimum value of 1.

The estimated export volume for each year corresponding to the magnitude of the location quotient are listed in the wholesale-retail trade (WRT) and services (S) columns. Based on these estimates, the portion of earnings attributable to exportation has grown more rapidly for services than wholesale-retail trade. Services export earnings increased 128 percent from 1949 to 1970.
while WRT only managed 36 percent for the same period. This is not surprising in the light of the trend toward providing more and more services at a regional and national level. The combination of these two estimated columns provides the data on earnings attributable to the tourist sector. This may be considered a gross estimation for it in no way distinguishes between a consumer who purchases within the region but lives outside and the actual tourist visiting the region. This gross measure is entirely useful given the definition of exportation operative in this study. Both types of spending in the above example are providing export income to the region.

**Federal Government**

The definition of an export sector operative in this study is based on an income flow concept. If the region under study had a currency different from the rest of the world then any activity which resulted in foreign currency flowing to the area would be classified as export. Under this concept, the earnings of the federal government sector are considered to be exogenous export earnings. Shift-share analysis of the earnings of the federal government sector in the study area are presented in Table 6.12. The data utilized are indicative of total earnings originating from the federal government sector, adjusted to real terms and expressed in millions of dollars.
### TABLE 6.12

**Federal Government 1 Shift-Share Analysis 1949-1970**

<table>
<thead>
<tr>
<th>Years</th>
<th>Total Units</th>
<th>Expected Change</th>
<th>Industry Mix</th>
<th>Regional Share</th>
<th>Total Change</th>
<th>Relative Change</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>I</td>
<td>II</td>
<td>Total - Growth</td>
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<td></td>
<td></td>
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<td>26.71</td>
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<td>0.02</td>
<td>0.39</td>
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<td>28.25</td>
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<td>1.84</td>
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<td>-7.21</td>
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<td>8.77</td>
</tr>
</tbody>
</table>

1 Explanation of the column headings is given in footnote 7 of the text, page 64.

2 Total Units = Total Agricultural Earnings By County, U.S. Department of Commerce. Expressed in millions of 1967 dollars. Data for '51-'58, '60-'61 and '63 were estimated by the author.
Expected Change—Growth. The expected annual growth path of federal government sector earnings in the study area, at the overall national rate, exhibits a stable positive growth with declines occurring only in 1957-1958, and 1968-1969. The actual growth experienced by the region's federal sector also exhibited a positive shift, with significant increases in 1958-1959, 1962-1963 and 1969-1970. This growth in general exceeded that which would have been expected at the national rate. This is probably due in large part to the extent of federal involvement in the region. Meade County, as it was pointed out earlier, is the site of an extensive military airbase. The region is also recipient of substantial federal funds for veterans health care.

Industry Mix. The federal sector over the 21 year period exhibits a net positive shift in the industry mix component (column 5). This signifies that, as measured by earnings, the sector could be characterized as a relatively rapid growth sector.

Regional Share. Inspection of the regional share column indicates that the federal sector has experienced a net downward shift in its regional share, relative to federal government operations in other regions.

Summary. The federal government sector: (1) has exhibited a growth path somewhat more rapid, and slightly more volatile than the expected growth of the national rate, (2) is a rapid growth
sector, and (3) as measured by the relative share component and compared to other regions has decreased over the time period.

**State and Local Government**

The growth of state and local government sectors throughout the nation is a phenomenon which is hardly new. The advent of partial decentralization of federal government control over programs and funds indicates that these sectors will continue to grow. The exogenous nature of the growth makes it imperative that this sector be included in an impact analysis. The shift-share analysis of the state and local government sector of the study area is presented in Table 6.13. The data utilized are total earnings, adjusted to real terms and expressed in millions of dollars.

**Expected Change—Growth.** Inspection of the expected growth column indicates that had the earnings of state and local government grown at the same rate as the national all industry rate, one could have expected a growth path which exhibited an upward trend over the 21-year period of analysis. Comparison with the total or actual change column, demonstrates that in every year earnings growth of this sector of the study area outperformed that which would have been expected. There were only two significant declines, 1961-1962 and 1964-1965, in an otherwise strong positive growth pattern.
<table>
<thead>
<tr>
<th>Years</th>
<th>Total Units</th>
<th>Expected Change</th>
<th>Industry Mix</th>
<th>Regional Share</th>
<th>Total Change</th>
<th>Relative Change</th>
</tr>
</thead>
<tbody>
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<td>1.15</td>
<td>+1.13</td>
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</tbody>
</table>

1. Explanation of the column headings is given in footnote 7 of the text, page 64.

2. Total Units = Total Agricultural Earnings By County, U.S. Department of Commerce. Expressed in millions of 1967 dollars. Data for '51-'58, '60-'61 and '63 were estimated by the author.
Industry Mix. Analysis of the industry mix component indicates that the state and local government sector experienced a rapid growth path nationally, i.e., net positive industry mix shifts relative to all national sectors. The only major exception being the 1968-1969 shift, which fell short of the national all sector shift by 1.72 million dollars.

Regional Share. The regional share component of the analysis indicates that the state and local government sector in the Black Hills region experienced an overall net positive shift during the 21 time periods. In the 1958 to 1966 period, however, this sector experienced a loss of position relative to the same sector in other regions. This may require a slightly special interpretation due to the nature of the sector. The relationship between output of this sector and total earnings originating within the sector is not as strong as for the competitive sectors considered earlier. The loss of position or negative shift in this period is more probably due to policy choices within the sector, i.e., a slowdown in government expenditures and/or growth.

Summary. One can conclude on the basis of the analysis presented here, that the state and local government sector of the Black Hills region: (1) experienced a growth path of a higher magnitude than that which would have been expected, (2) exhibited a higher growth which was partly due to the rapid growth nature of
the sector nationwide, and (3) experienced a net positive shift in its growth relative to the same sectors in other regions.
Chapter 7

REDUCED FORM MULTIPLIERS: AN EMPirical
ESTIMATION AND INTERPRETATION

Having considered descriptively the economic sectors of major
importance in this analysis, the reduced form of the structured
economic model was estimated by the use of multiple regression.
The results of that estimation are presented in this chapter along
with the extension of those results to a dynamic multiplier
analysis of the Black Hills region. Specifically, this chapter
is divided into two parts: (1) a presentation and discussion of
the multipliers estimated from the reduced form relations; and
(2) application of the reduced form analysis to multiperiod
dynamics.

Estimated Dynamic Reduced Form Multipliers

When applied empirically the method of reduced-form analysis
has many advantages over other methods in multiplier estimation.
The first of these advantages lies in the general nature of the
method: It can be applied to any number of equations of an
economic system and concentration can be placed upon certain
relationships of interest without consideration of the entire
structural system. This has important ramifications for the
regional researcher in that the complexities introduced by the lack of complete regional accounts is greatly alleviated. As long as it is desired to measure the impact of exogenous variables, some of which may be susceptible to policy manipulations, on certain key endogenous variables, this may be accomplished with a reasonable amount of secondary data requirements. The major limitation of the method is that no estimates are derived for the structural parameters--marginal propensities, etc.--and thus if prediction of the changes in an economic system due to changes in the structural parameters is desired, this method will not produce this information. This is not seen to be a serious consequence for the objectives of this study.

The reduced form system was applied to time series data for the Black Hills region of South Dakota. The equations of main interest, for which estimates of parameters were devised, are those relating personal income, wage and salary income, and personal returns to capital, to changes in the exogenous variables of agriculture, mining, wholesale-retail trade and service exports, federal government and state and local government. The economic status of these exogenous sectors are assumed to be reflected in their respective level of total earnings. Personal income, wage and salary income and personal returns to capital are therefore assumed to be directly influenced by earnings in each of the exogenous sectors.
The model estimated by direct least-squares, for the Black Hills region was:

\[
\begin{align*}
    P_t &= a_1 + \pi W_{-1} + \pi K_{-1} + \pi AG_t + \pi MNG_t + \pi WRSE_t + \pi (FG_t + SLG_t) \\
        &+ \pi t + e_{1t} \\
    W_t &= a_2 + \pi W_{-1} + \pi K_{-1} + \pi AG_t + \pi MNG_t + \pi WRSE_t + \pi (FG_t + SLG_t) \\
        &+ \pi t + e_{2t} \\
    K_t &= a_3 + \pi W_{-1} + \pi K_{-1} + \pi AG_t + \pi MNG_t + \pi WRSE_t + \pi (FG_t + SLG_t) \\
        &+ \pi t + e_{3t}
\end{align*}
\]

Where:

- \( P \) = Personal Income of the residents of the Black Hills region.
- \( W \) = Wage and Salary Income + other Labor Income.
- \( K \) = Personal Returns to Capital, i.e., (proprietors income + property income).
- \( AG \) = Total Agricultural Earnings.
- \( MNG \) = Total Mining Earnings.
- \( WRSE \) = Estimated export volume of the combined Wholesale-Retail Trade and Service sectors.
- \( FG \) = Total Federal Government Earnings.
- \( SLG \) = Total State and Local Government Earnings.
- \( t \) = exogenous time component.

All data have been adjusted to real terms and are expressed in millions of dollars. The estimated dynamic model is then:

\[
(7.1) \quad P_t = -93.5 + 2.2053 W_{-1} -2.1049 K_{-1} -0.4726 EG_t \\
        + 7.7049 MNG_t + 1.3056 AG_t + 1.8359 WRSE_t -0.18 t
\]

\( R^2 = 0.99 \quad F = 98.68 \)
(7.2) \[ W_t = -125.12 + 1.0373 W_{-1} -0.7229 K_{-1} + 0.9402 \Sigma G_t \]
\[ + 3.7070 MNG_t + 1.272 AG_t + 2.7968 \text{WRSE} -4.6 t \]
\[ R^2 = 0.99 \quad F = 59.43 \]

(7.3) \[ K_t = -6.5 + 0.5479 W_{-1} -0.4570 K_{-1} -0.4240 \Sigma G_t \]
\[ + 2.3066 MNG_t + 0.5883 AG_t -0.03711 \text{WRSE} + 1.95 t \]
\[ R^2 = 0.99 \quad F = 63.55 \]

For convenience the reduced form multipliers of the dynamic model are presented in matrix form. The estimated multipliers are presented in Table 7.1.

### TABLE 7.1

<table>
<thead>
<tr>
<th>( W_{-1} )</th>
<th>( K_{-1} )</th>
<th>( \Sigma G )</th>
<th>MNG</th>
<th>AG</th>
<th>WRSE</th>
<th>t</th>
<th>Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>2.2053</td>
<td>-2.1049</td>
<td>-0.4726</td>
<td>+7.7049</td>
<td>1.3056</td>
<td>1.8356</td>
<td>-0.18</td>
</tr>
<tr>
<td>W</td>
<td>1.0373</td>
<td>-0.7229</td>
<td>0.9402</td>
<td>+3.7070</td>
<td>1.2172</td>
<td>2.7968</td>
<td>-4.6</td>
</tr>
<tr>
<td>K</td>
<td>0.5479</td>
<td>-0.4570</td>
<td>-0.4240</td>
<td>2.3066</td>
<td>0.5883</td>
<td>-0.03711</td>
<td>1.95</td>
</tr>
</tbody>
</table>

As each of the equations in the dynamic model contains lagged endogenous variables, tests of individual coefficients (t-statistics) are not possible. In order to check the reliability of the estimated equations, the observed or actual data was plotted against the forecast or expected data using each of the estimated equations. These results are presented in Figures 7.1 through 7.3. As can be seen, the forecast values over the sample period fit the actual data points rather well. The test of a forecast equation
lies in its ability to track or follow the turning points of the actual data. The estimated equations exhibit such an ability to forecast the turning points in the endogenous variables. Figure 7.1 depicts the time path of personal income for the study area from 1951 to 1970. Of the seven turning points in personal income the estimated equation (7.1) failed to forecast only one, the downturn from 1958 to 1959. Likewise the wage and salary equation (7.2) correctly forecast five of seven turning points in regional wage and salary income, Figure 7.2. The personal returns to capital equation (7.3) performed equally as well as the first two, missing only the 1958 to 1959 downswing, as is evident from Figure 7.3.

Interpretation of the Results

It is of interest to analysts and policy-makers to know the time path of the response in regional income as well as the ultimate long-run response. The operating horizon of decision makers is generally limited and is seldom an infinite number of years into the future. Even if it is desired to know what the long-run impact of a particular decision will be, the economic and social system with which the analyst must deal may not be susceptible to such an extended period of direct control required for the attainment of the ultimate response. The analyst and policy makers are therefore constrained to focus on the responses which will occur in the short-
Figure 7.1

Observed vs Forecast Personal Income for the Black Hills Regional Economy 1951-1970
Figure 7.2

Observed vs Forecast Wage and Salary Income for the Black Hills Regional Economy 1951-1970

- Observed W 1951-1970
- Forecast W 1951-1970
Figure 7.3

Observed vs Forecast Personal Returns to Capital for the Black Hills Regional Economy 1951-1970
run. Earlier work of Machlup\textsuperscript{1} and Metzler\textsuperscript{2} have indicated that there exist various lags in the circular income flow which postpone the attainment of a new equilibrium when the economy adjusts to a new level of autonomous expenditure. The estimated parameters of the dynamic model are thus directly applicable to this task as well as that of estimating the long-run impacts or responses.

The estimated reduced form multiplier matrix presented in Table 7.1 may then be partitioned in the manner considered in Chapter 4, page 37. The A-matrix of coefficients of the lagged dependent variables is then:

\[
A = \begin{pmatrix}
0 & 2.2053 & -2.1049 \\
0 & 1.0373 & -0.7229 \\
0 & 0.5479 & -0.4570 \\
\end{pmatrix}
\]

The \( P_{-1} \) column contains only zero's. No lagged value of the dependent variable personal income is included in the model because given that \( P_t = W_t + K_t \) inclusion of \( W_{-1} \) and \( K_{-1} \) adequately reflects the relationships of \( P_t = f(P_{t-1}) \).


The partitioned reduced form matrix $\Pi'$ now has as its sub-sector matrix $B$. This is given as:

$$
\begin{pmatrix}
P & -0.4726 & 7.7049 & 1.3056 & 1.8359 & -0.18 \\
B = W & -0.9402 & 3.7070 & 1.2172 & 2.7968 & -4.6 \\
K & -0.4240 & 2.3066 & 0.5883 & -0.0371 & +1.95
\end{pmatrix}
$$

The coefficients of this submatrix represent the contemporaneous or impact multiplier responses to a change in an exogenous variable. These impacts must be differentiated from the typical Keynesian timeless multiplier in that they refer to a specific period, and also represent the interaction of endogenous variables upon each other. Thus the impact in the initial period of government earnings on personal income of $-0.4726$ is not to be construed as a negative multiplier. The coefficient represents the impact of changes in government earnings after taking into account the interaction of differing impacts on wage and salary income and personal returns to capital. Indeed, as will be seen, the long run impact of changes in government earnings is positive on personal income.

Examination of the coefficients presented in the $B$-matrix, suggests that the disaggregated export sectors have differing relative initial impacts on each of the measures of income in the study areas. The contemporaneous response of all three income variables is relatively larger for the mining sector than for the other export sectors. Why is this so? One would think that an autonomous change of one dollar would have equal initial and multiple impacts
on personal income regardless of the export sector in which it is
generated. That it does not can be explained in the following
manner. The magnitude of the multiplier depends on (1) the
marginal and average propensities to consume and import of the
recipients of wage earnings and profits and (2) the distribution
of income between wages and profits and among income level classes.3
Thus, a sector which has a higher proportion of total earnings
flowing to the usually higher marginal and average spending wage
earners would exhibit a larger impact on income in the initial
period as well as in the long-run equilibrium response. This is
only true as long as the wage recipients have a low marginal and
average propensity to import for consumption. Theoretical and
empirical investigation concerned with the behavior of average and
marginal consumption given differing income levels tend to support
this hypothesis.4 Wage earners exhibit a higher marginal propensity
to spend and are not a large importing class as compared to the
profit recipient group.

In terms of the estimates of this study this means that given
a unit change in an explanatory -- exporting sector -- variable,
the response in the expected or average value of the endogenous --

3For example see Paul Davidson "Income and Employment Multi-
pliers, and the Price Level," American Economic Review, 1964,
pp. 739-752.

4Shapiro, Edward Macroeconomic Analysis, 2nd ed. (New York:
income — variable will be larger for those sectors which have a larger percentage of earnings flowing to wages and salaries and less to profits.  

By examining the estimated coefficients of the B-matrix it is evident that mining has the largest initial impact (7.70) on income in the region. This would suggest that the earnings from the mining sector flow more directly, and possibly with a greater proportion to the wage earner relative to the other sectors considered. The estimated negative initial response (-0.47) of personal income (P) to a unit change in government earnings indicates that shifts in this sector, at least initially, have depressing effects upon the level of personal income in the region. The responses of the components of personal income — W and K — to a change in government earnings indicate that expected level of profits would decrease and wage income increase. This suggests that as government earnings are increasing, regional personal income is responding with a contemporaneous decrease due to shifting of spending away from those activities which have a profit component (-0.42) to wage income which does not have such a component (+0.94). The estimated response of personal income and its components to a change in earnings originating in the wholesale-retail trade and service sector and the agricultural sector are very similar, being (1.83) and (1.30), respectively.
The contemporaneous or initial responses indicated by the estimated coefficients of the B-matrix yield the first insight into the response of personal income to changes in the export sectors of the dynamic model. Additional information as to the response of personal income in succeeding periods is derived by use of the Black Hills dynamic model and the matrix operations discussed in Chapter 4, pp. 37-41.

**Multiperiod Analysis**

By repeated use of equations (4.17) and (4.19), the annual responses as well as the cumulative responses were estimated for a five year period for all of the exogenous variables. The results are presented in Tables (7.2) to (7.8).

**TABLE 7.2**

**Impact Multipliers**

Initial Response of Endogenous Variables to a Unit Change in Exogenous Variables: \( t = 0 \)

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>( \delta G )</th>
<th>( MNG )</th>
<th>( AG )</th>
<th>( WRSE )</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>P . . . . .</td>
<td>-0.47</td>
<td>7.70</td>
<td>1.30</td>
<td>1.83</td>
<td>-0.18</td>
</tr>
<tr>
<td>W . . . . .</td>
<td>0.94</td>
<td>3.70</td>
<td>1.21</td>
<td>2.79</td>
<td>-4.66</td>
</tr>
<tr>
<td>K . . . . .</td>
<td>-0.42</td>
<td>2.30</td>
<td>0.58</td>
<td>-0.03</td>
<td>1.95</td>
</tr>
</tbody>
</table>
### TABLE 7.3

Response of Endogenous Variables to a Unit Change in Exogenous Variables in the First Year: \( t = 1 \)

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>EG</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EG</td>
</tr>
<tr>
<td>P . . . . .</td>
<td>2.96</td>
<td>3.31</td>
</tr>
<tr>
<td>W . . . . .</td>
<td>1.28</td>
<td>2.17</td>
</tr>
<tr>
<td>K . . . . .</td>
<td>0.70</td>
<td>0.97</td>
</tr>
</tbody>
</table>

### TABLE 7.4

Response of Endogenous Variables to a Unit Change in Exogenous Variables in the Second Year: \( t = 2 \)

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>EG</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EG</td>
</tr>
<tr>
<td>P . . . . .</td>
<td>1.33</td>
<td>2.74</td>
</tr>
<tr>
<td>W . . . . .</td>
<td>0.81</td>
<td>1.55</td>
</tr>
<tr>
<td>K . . . . .</td>
<td>0.37</td>
<td>0.74</td>
</tr>
</tbody>
</table>

### TABLE 7.5

Response of Endogenous Variables to a Unit Change in Exogenous Variables in the Third Year: \( t = 3 \)

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>EG</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EG</td>
</tr>
<tr>
<td>P . . . . .</td>
<td>1.00</td>
<td>1.85</td>
</tr>
<tr>
<td>W . . . . .</td>
<td>0.57</td>
<td>1.07</td>
</tr>
<tr>
<td>K . . . . .</td>
<td>0.27</td>
<td>0.50</td>
</tr>
</tbody>
</table>
TABLE 7.6

Response of Endogenous Variables to a Unit Change in Exogenous Variables in the Fourth Year: \( t = 4 \)

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>EG</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0.68</td>
<td>1.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-3.35</td>
</tr>
<tr>
<td>W</td>
<td>0.39</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1.93</td>
</tr>
<tr>
<td>K</td>
<td>0.18</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.92</td>
</tr>
</tbody>
</table>

TABLE 7.7

Response of Endogenous Variables to a Unit Change in Exogenous Variables in the Fifth Year: \( t = 5 \)

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>EG</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0.47</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-2.32</td>
</tr>
<tr>
<td>W</td>
<td>0.27</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1.34</td>
</tr>
<tr>
<td>K</td>
<td>0.13</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.63</td>
</tr>
</tbody>
</table>

TABLE 7.8

Cumulative Response of the Endogenous Variables to a Unit Change in the Exogenous Variables \( t = 5 \)

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>EG</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>5.97</td>
<td>17.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.31</td>
</tr>
<tr>
<td>W</td>
<td>4.26</td>
<td>9.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.52</td>
</tr>
<tr>
<td>K</td>
<td>1.23</td>
<td>5.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.78</td>
</tr>
</tbody>
</table>
The value of the multiperiod analysis of the impact can be seen by examining the entries of Tables 7.2 through 7.7. The estimated initial responses of personal income and its components are given in Table 7.2 and have already been discussed. These initial responses yield information about the impact on the system of a contemporaneous adjustment of personal income to a unit change in one of the exogenous variables (export sectors). However, these initial responses do not stop at the end of the period but continue in a series of secondary, cross-temporal responses. Thus, time paths of the estimated secondary or delay responses are given in Tables 7.3 and 7.4.

The government earnings variable which had an estimated negative initial impact on personal income can be seen to exert a positive cross-temporal impact of (2.06) in the first year, and continued positive impacts in each succeeding year. The additional income in the hands of government earnings recipients would, by the second and subsequent period, begin to have a positive impact on profits in the rest of the region. This is supported by the positive response of profits (K) in the second and successive time periods.

The estimated response of personal income to a unit change in the estimated earnings of wholesale-retail trade and service exports exhibit a rather interesting property. Although the initial impact (1.83) on personal income is not much greater than that of
agriculture (1.30) there exists a one period lag between a unit change in this exogenous sector and when the largest impact on personal income and its components is fully felt. This would suggest perhaps that the seasonal nature of this sector would have an important influence upon any impacts which would be felt in the region from a change in this sector.

The explicit time trend \( t \) requires a rather special interpretation in dynamic analysis. As time must increase by a unit for each new period of the dynamic analysis, it makes little sense to think of a unit change in time as either one-shot or sustained change, as with the previous analysis. The time component represents actually a unit change in other factors not considered in the functional relationship of the dynamic model. At the same time, the included sectors are held statistically constant -- *ceteris paribus*. It would therefore seem reasonable to expect that if the dynamic model explains the endogenous variables rather well, by holding the explanatory variables constant and considering only a unit change in the explicit time variable \( t \), one would find a decline in the real income of the region. This is supported by the relatively large negative impact exhibited in the first year of the dynamic analysis (-14.382).

The cumulative responses of personal income and its components are given in Table 7.8 Each coefficient of the table gives the estimated response of the different measures of income to a one-
shot change in the exogenous variables. Thus, given the initial
negative response of personal income to a one-shot increase in
government earnings plus the sum of the delayed responses for the
following five time periods, the cumulative response of personal
income is 5.97. What is evident from the estimates of Table 7.8
is that the mining (MNG) and estimated tourism (WRSE) sectors yield
the largest relative response in regional income as compared to the
other sectors. Agriculture and government earnings tend to have
similar impacts on wage and salary income as well as personal
returns to capital and hence on total personal income.

Dynamic Equilibrium Analysis

Analysis of various responses in regional personal income to
unit changes in the exogenous sectors provides valuable information
as to the initial and delayed impacts of each of the various sectors.
However, an important point of the analysis is also concerned with
the answer to the question, "What are the relative long-run or
equilibrium impacts associated either with an impulse change or
sustained change in the exogenous sector?" Before considering the
answer to this question, a distinction must be made between a cumu-
lative equilibrium impact resulting from an impulse change and an
aggregate impact resulting from sustained change. The cumulative
impact case has already been considered. This is nothing more than
the accumulation of each of the cross-temporal impacts in Tables
7.3 through 7.7, and the initial impact in each case. The aggregate
impact or response is interpreted in a slightly different manner although the magnitude of the responses are the same in both cases. The aggregate response refers to the impact felt in any year after a sufficient period of time has elapsed so that the secondary effects from the first sustained change have gone to zero. The aggregate response is then a continuous process as long as the unit change in one exogenous variable is maintained.  

For example, drawing from the estimated responses of personal income presented in Tables 7.2-7.7 the equality of the aggregate and cumulative responses can be demonstrated. As the data used are actual estimates for 5 years the secondary effects have not been allowed sufficient time to converge to zero. However, the use of actual data still reflects the principle to be demonstrated here. Consider then:

<table>
<thead>
<tr>
<th>t</th>
<th>Change in Exogenous Variable</th>
<th>Response of Endogenous Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>-0.47</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>-0.47 → 2.96</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>-0.47 → 2.96 → 1.33</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>-0.47 → 2.96 → 1.33 → 1.00</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>-0.47 → 2.96 → 1.33 → 1.00 → 0.68</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>-0.47 → 2.96 → 1.33 → 1.00 → 0.68 → 0.47</td>
</tr>
</tbody>
</table>

The figures in the example represent the combination of both an impulse or cumulative response and a sustained or aggregate response of personal income to a unit change in government earnings. By considering only the initial change (1 unit) and the cross-temporal responses on the main diagonal, the magnitude of the cumulative response may be seen as 5.97 units. The aggregate response for any
By employing equation (4.20) the long-run responses of the dynamic system can be evaluated. These are given in Table 7.9 for the Black Hills dynamic model.

**TABLE 7.9**

Long-Run or Equilibrium Response of Endogenous Variables to an Impulse or Sustained Unit Change in Exogenous Variables

<table>
<thead>
<tr>
<th>Endogenous Variables</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G</td>
</tr>
<tr>
<td>P</td>
<td>5.40</td>
</tr>
<tr>
<td>W</td>
<td>3.72</td>
</tr>
<tr>
<td>K</td>
<td>1.10</td>
</tr>
</tbody>
</table>

*The values presented here are not identical with those calculated by the direct summing of each individual response. These are an approximation to an infinite series and are interpreted as limiting values.

As is evident from the estimates presented in Table 7.9, the relative magnitude of the response associated with a unit change in the mining sector, although much larger initially than the other sectors as given in Table 7.2, is only slightly larger than WRSE sector in the long-run. A unit change in mining will have a long-run response on personal income of +16.089 units. The long-run given year is calculated by summing across horizontally and not diagonally. Thus the equilibrium or long-run aggregate response in this simple example is also equal to 5.97 in the fifth year. Summing across this row equals 5.97. As long as the exogenous change is sustained, and assuming that the secondary impacts stemming from the first or initial period have converged to zero, the aggregate response for each succeeding period will be maintained.
response to a unit change in estimated wholesale-retail and service exports is +14.762 units. This latter sector exhibits a slightly larger impact on wage and salary incomes than does any of the other sectors. This is possibly due to the relatively larger proportion of total income flowing into wage and salary incomes in this sector. As expected, agriculture, a sector which can be characterized as a low wage sector and which has been undergoing steady capital-labor substitution, exhibits the smallest long-run impact on the wage and salary component of personal income. Agriculture also exhibits a relatively small long-run impact on personal returns to capital. Taken in combination, the size of agriculture's equilibrium impact on personal income is the smallest of the sectors considered.

The government sector exhibits a long-run impact on personal income and its components very similar, although somewhat larger, to that of agriculture. As indicated earlier, the initial response of the endogenous variables personal income and profits to a unit change in government earnings is negative. However, the estimated long-run response, allowing for cross-temporal feedback between the individual responses of wage and salary income and personal returns to capital, indicates that a unit change in this sector has a positive impact on the regional economy.
Static Analysis

The dynamic analysis provides information as to the response of personal income to a unit change in any of the exogenous variables -- export sectors. However, it is reasonable to expect that certain exogenous variables make larger contributions to the overall variation in personal income. Thus an important question becomes, "Which sectors exhibit the largest relative contribution to explaining the variation of personal income over the sample period?"

The answer to this question can be explored by formulating the functional equation:

\begin{equation}
\text{Pt} = a_{10} + a_{11} \Sigma G + a_{12} \text{MNG} + a_{13} \text{AG} + a_{14} \text{WRSE} + a_{15} t
\end{equation}

Where: personal income is a function of government earnings (\(\Sigma G\)), mining earnings (\(\text{MNG}\)), agricultural earnings (\(\text{AG}\)), estimated wholesale-retail trade and services earnings (\(\text{WRSE}\)) and an explicit time trend component (\(t\)), -- and estimating the standardized partial regression coefficients\(^8\) for each of the exogenous variables. The

\(^8\) The standardized partial regression coefficient is calculated by expressing changes in the exogenous variables as units of their own standard deviation. Thus the standardized value is calculated as:

\[
\bar{b}_i = b_i \frac{S_{x_i}}{S_y}
\]

Where \(\bar{b}_i = \) standardized value; \(b_i = \) partial regression coefficient; \(S_{x_i}, S_y = \) standard deviation of \(x_i\) and \(y\), respectively. The standardized coefficients (\(\bar{b}_i\)) are interpreted as: the effect of a unit standard deviation change from the mean of \(x_i\) will result in a (\(\bar{b}_i\)) unit standard deviation change from the mean of \(y\). Standardized regression coefficients are usually referred to as Beta coefficients.
estimated equation (7.4) is:

\[
\begin{align*}
P_t &= -234.0 + 4.7124 \Sigma G_t + 9.7075 MNG_t + 2.4099 AG_t \\
&+ 4.9843 \text{WRSE} - 13.24 t \\
&\quad (2.24) \quad (1.49) \quad (3.28) \quad (1.40) \quad (-1.57) \\
R^2 &= 0.99 \\
F &= 22.06
\end{align*}
\]

Significance tests of the individual coefficients (t-statistics) are given in parenthesis below each coefficient. All of the estimated coefficients are statistically significant at the .10 percent level, with government and agriculture being significant at the .05 percent level. The estimated equation explains roughly 99 percent of the variation in personal income as measured by the coefficient of multiple determination -- \( R^2 = .99 \). Significance of the overall equation was checked by use of the F statistic and was found to be significant at the .01 percent level -- \( F = 22.06 \).

The standardized (Beta) coefficients and the partial regression coefficients for equation (7.5) are given in Table 7.10.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Exogenous Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta</td>
<td>( \Sigma G ) 1.7360</td>
</tr>
<tr>
<td>Partial Regression</td>
<td>4.7124</td>
</tr>
</tbody>
</table>
By standardizing the partial regression coefficients the relative magnitude of the contribution to personal income by each individual sector can be seen. Thus it becomes apparent that the growth of the government earnings sector has had the largest influence (1.73) on personal income in the study area, followed by estimated wholesale-retail trade and services export earnings (0.63). Mining (0.36) and agriculture (0.35) are seen to have contributed roughly the same to the level of regional personal income.

The estimated Beta coefficients tell us that during the period 1950-1970, the growth of government earnings have contributed the most to the growth of personal income in the Black Hills region. It becomes a matter of policy therefore to ascertain whether this growth rate of the government sector can be continued indefinitely into the future. As was demonstrated by the dynamic impact analysis, an increase in mining earnings has a multiple effect upon personal income in the study area roughly three times that of an identical unit increase in government earnings. Government earnings have grown much faster than mining earnings, and therefore made a larger contribution to regional personal income. This same regional income is more sensitive to fluctuation in mining income.

Marginal Spending Analysis

The results of the reduced form analysis indicate that the primary export sectors exhibit relatively large desparities of impact on regional personal income. By specifying the multiplier
in the general form \( M = \frac{1}{1-S} \) where \( S \) is the adjusted marginal propensity to spend locally, and solving for \( S = \frac{1-M}{1} \), these disparities can be traced to differing spending patterns or behavior for each sector. By estimating the magnitude of the mps (s) for each sector included in the analysis, it is possible to compare the marginal spending behavior of the different sectors. This comparison provides insights into the possible distribution of income between the wage and salary and profit recipients and between income classes. Table 7.11 presents the estimate marginal propensities to spend, as calculated from the dynamic multiplier estimates for each export sector.

---

1The actual specification of the multipliers estimated in this study are of the form:

\[
m = \frac{1}{1 - (b (1-f) + d) - h}
\]

where:

- \( b \) = marginal propensity to consume
- \( f \) = marginal propensity to tax and is equal to 0
- \( d \) = marginal propensity to invest
- \( h \) = marginal propensity to import

Although the actual magnitude of these parameters is not known for the regional economy in the study area, by reformulating the multiplier into

\[
m = \frac{1}{1-s}
\]

where: \( s = [(b (1-f) + d) - h] \), adjusted marginal propensity to spend, and solving for \( s \), estimates of the mps for each sector can be arrived at \( - s = - \frac{1-m}{1} \). It should be recognized that in this model, (f) the marginal propensity to tax additional income is set equal to zero by the use of gross income and earnings data, and therefore estimates of \( s \) will be inflated by an amount proportional to \( f \) for each sector.
### TABLE 7.11

Estimated Marginal Propensities to Spend: By Export Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Estimated MPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>0.94</td>
</tr>
<tr>
<td>Wholesale-Retail Trade</td>
<td>0.93</td>
</tr>
<tr>
<td>Government</td>
<td>0.81</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.78</td>
</tr>
</tbody>
</table>

By calculating the marginal spending propensities for each sector it is apparent that additional income flowing into the region via the sectors of mining and wholesale-retail trade exports is respent in a larger proportion relative to the sectors of government and agriculture. The estimated mps for mining of 0.94 suggests that 94 cents out of each additional dollar is respent within the region. This interpretation also applies to the remaining three sectors. The relatively high mps' for mining and wholesale-retail trade suggests that these two sectors are more closely tied to the regional economy than the other sectors and that they experience a lower leakage of earnings out of the region.

Summary

The mining sector exhibits the largest initial impact on personal income, and also the largest long-run response. The sector which has the second largest long-run impact on the region's
personal income is that of estimated wholesale-retail and service exports. The analysis suggests that a lag exists in this sector and that the largest period response occurs not in the initial, or same period as the unit change, but in the succeeding or first period thereafter. Government earnings has the third largest impact on personal income, followed by agricultural earnings. These findings are not surprising in light of the descriptive analysis of these sectors presented in Chapter 6. From that earlier analysis it will be remembered that the Black Hills region was delineated by the geographic uniqueness which contributed to the area. The magnitudes of the estimated multipliers are difficult to verify because of the lack of comparable studies for other regions. However, a dynamic analysis conducted by Goldberger on the reduced form of the Klein-Goldberger model suggests that the actual government multiplier is significantly larger than the simple timeless Keynesian estimate of 2 or 2.5. The estimate of the government sector multiplier using the Klein-Goldberger reduced form model is approximately 4.922. This is not largely different from that found in this study of +5.400 for government earnings. A possible limitation with respect to the magnitude of the estimates derived herein, is that taxes are considered exogenous, i.e., tax yield is assumed to be

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set by policy, and thus any possible dampening effects of increased tax burden with the expansion of income is not operative. Thus the estimated long-run multipliers of this study are not influenced by rising tax yields as income expands. Therefore, estimates are somewhat larger than similar estimates would be if derived with taxes included as an endogenous and interacting variable in the model. The results for each sector can be summarized in the following manner:

**Mining**

The mining sector of the study area was estimated to have the largest equilibrium impact on personal income. This was seen to be due to a large initial import (+7.70), tapering off to a long run impact of 16.08. The magnitude of this estimated impact yields a marginal propensity to spend for this sector equal to 0.94.

**Wholesale-Retail Trade and Services Exports**

This sector was included in the study as a proxy variable to estimate the influence of tourist expenditures on personal income. This analysis indicates that this sector has an overall impact on income only slightly less than that of the mining sector. The estimated equilibrium multiplier for this sector was 14.76. The analysis also revealed an interesting property of dynamic time path of regional income in response to a unit change in this sector.
There exists a one period lag in the response of regional income to a change in tourist earnings, with the largest income response (6.24) occurring in the first period and not the initial period. The estimated marginal propensity to spend of this sector is 0.93 suggesting a similarity between the behavior patterns of this sector's earnings recipients and those in the mining sector.

**Government**

The initial impact of government earnings on personal income is negative, suggesting that positive changes in this sector result, initially at least, in a shifting of funds and not increased total expenditure from this sector. The delayed responses and subsequent positive equilibrium multiplier +5.40 indicate that the flow of dollars from the initial recipients has a positive effect on profits of the region and hence positive total impact on personal income. The magnitude of the estimated multiplier (5.40) for this sector suggests that the marginal propensity to spend of the income recipients of this sector is approximately equal to 0.81.

**Agricultural**

The estimated equilibrium income multiplier for unit changes in agricultural earnings is the smallest of the multiplier estimates relative to the other sectors (4.68). The time path of the response of income and its components to a unit change in agricultural earnings is estimated to be rather stable and only slightly
smaller than that of government earnings. Employing the estimated long run multiplier for agricultural earnings suggests that the marginal propensity to spend for this sector is approximately equal to 0.78.
Chapter 8

CONCLUSIONS, POLICY IMPLICATIONS, LIMITATIONS, AND COMPLEMENTARY RESEARCH

The importance of determining the impacts of economic policy decisions on the structure and performance of a regional economy before the actual implementation of such decisions is largely self-evident. All too often, programs and policies are set in motion and subsequently result in adverse regional impacts. Alternatively programs which are designed to influence and stimulate regional economic growth tend to have little effect upon the target economy. Both of these types of effects are partly attributable to a specific lack of information concerning the primacy of individual income producing sectors in determining regional income levels and variations therein. It is toward the fulfillment of this informational gap that this investigation has addressed itself.

The purpose of this study was to explore a practical method for estimating the relative importance of the primary economic sectors of a regional economy and the dynamic multipliers of these sectors with respect to regional income. A secondary purpose was the application of this method to the Black Hills regional economy. Economic growth theory provided the basis for selection of the sectors included in the study. Utilization of the econometric
method of dynamic reduced form analysis established the framework
for the estimation process.

The research focused on these main areas: (1) the delineation
of primary economic sectors which explain variations in regional
income based on economic growth theory, (2) transformation of the
theoretical economic explanation into a dynamic regional income
model and interpretation of the models inherent dynamic properties,
(3) direct application of the model in estimating the impacts which
selected exogeneous economic sectors have on regional income in the
Black Hills region of South Dakota, and (4) interpretation of the
estimates derived from the econometric model as they might be applied
to current and future policy decisions.

Study Conclusions

The research undertaken in this study was based principally on
two main hypotheses. First it was hypothesized that those sectors
of a regional economy which are export orientated have a primary in-
fluence in determining the level of regional income and in explaining
the variation therein. An extension of this hypothesis is that these
sectors exhibit differing impacts on regional income which are not
adequately measured by utilization of an aggregate export income
concept. The second hypothesis was that the individual export sector
multipliers can be estimated by the development and utilization of
a dynamic reduced form econometric model. The results of this
research effort bear out these hypotheses.
The results indicate that variations of personal income, and its components wage and salary income and personal returns to capital, can be adequately explained by the use of a properly constructed reduced form model in which regional personal income is expressed as a linear function of the primary export sectors in that region. The regional model developed and estimated explained approximately 99 percent of the variation in personal income for the Black Hills region of South Dakota.

It was also found that the primary export sectors exhibit relatively large disparities of impact on regional personal income and its components. Direct aggregation of each sector into a larger sector representing all export earnings would produce a bias estimate of the export income multiplier. Each sector included in the analysis has a separate impact on regional income which may not be similar to the multipliers for other export sectors. This difference is due to the magnitude of the marginal spending propensities for each sector's income recipients. The results of this research indicate that the magnitude of these differences can be estimated by the use of a reduced form econometric model.

Policy Implications

The multiplier estimates derived from this research have specific ramifications for policy choices and decisions in the study area.
Changes in the mining sector earnings of the Black Hills region has the largest impact on regional income relative to the other sectors. Thus it can be stated that this sector will yield the largest bang for the buck. In considering specific policy alternatives in light of this it should be kept in mind that the continued propensity of this sector relies very heavily on the continued availability of the mineral resources, which are fixed in the long run. Low reserves could have a limiting effect on expansion in this area. Also environmental considerations could conceivably limit or at least slow the growth of this sector. However it is possible that recent national and international monetary decisions and higher gold bullion prices could offset to a certain extent these limiting factors.

Changes in the wholesale-retail trade and service export sector has an estimated effect on personal income only slightly less than that of mining, with a delayed initial impact on income. This tourist expenditure proxy suggests that this sector could be the leading determinant of regional income in the future. Rising national income has resulted in more leisure time and increased tourism activity. Caution should be exercised in placing a large regional dependency on this sector. National income fluctuations and autonomous changes in peoples preferences could tend to make tourism an unstable income generation sector. This volatility could cause income fluctuations in the Black Hills region.
complex functional economic relations operative in a region. Unfortunately the necessity to abstraction requires the introduction of limitations of any method of analysis. However, knowledge of the limiting factors is not the end of wisdom but the beginning. Adequate information as to the limitations of a particular method should aid in the proper application and interpretation of that method and also illuminate the areas in which improvement may be sought. It is toward this end that the limitations of this research are clearly specified.

The limitations of this study can be classified into three main areas which are separate, but not totally distinct from one another. The areas are: (1) problems of statistical estimation in employing the technique, (2) the inadequacy of existing regional accounts, and (3) nature of this specific method applied at the regional level.

**Statistical Limitations on Technique**

The technique utilized in this research is subject to certain limitations as is any other technique. Proper interpretation of the results of this research requires that these limitations be understood.

The impact coefficients derived in this research are statistical estimates of true population parameters. They are arrived at only after certain statistical properties are assumed to be satisfied. Violation of these statistical assumptions introduces a degree of bias to the estimated parameters. The use of actual economic data
seldom provides the researcher with a setting in which all of the
statistical assumptions are perfectly satisfied. This does not
suggest that any attempt to estimate the true population parameters
is futile, only that the estimates are just that and should be
interpreted as such.

The statistical estimation of the parameters of an econometric
model is based on the assumption that each of the explanatory
variables is independent from the other. This is rarely the case
in economic data. Correlation between economic data series occurs
when sample observations over a specified time period are used.
Difficulty arises in sorting out the individual impacts of the
exogenous variables on the endogenous variables as the system
progresses from $t$ to $t + n$. In this study the sectors of federal
and state and local government were combined into the government
earnings sector due to the large (0.9) correlation between these
individual time series. The correlations between the other exogene-
ous sectors, although larger than optimally desired, were not
considered large enough to severely affect or impair the estimation
of the reduced form equations.

The third limitation of this method relates to the size of the
region delineated. It is obvious that the use of the technique
employed here would yield different results if the region delineated
was comprised of all economies, i.e., the world, as opposed to a
region defined by a county. The results obtained from the use of
Reduced form and regression analysis are sensitive to the size of the regional economy employed. To define a region of extremely small size may by definition limit the effective impact which a sector may have on regional income, and vice versa. Thus, the physical size and market structure of an area should be carefully considered when delineating the area of study, and interpreting the results obtained.

Inadequacy of Regional Accounts

The estimation of the parameters of an econometric model can be only as accurate as the data upon which the estimation rests. At the regional level, especially the rural taxonomy, regional accounts, which reflect the income originating within specific economic sectors, are not available. This necessitates the use of data series which are available as proxies for the desired information and may lead to some misspecification. In this study earnings by sector were substituted for total income originating by sector. The implicit assumption was that changes in earnings are adequate and rapid reflections of the change in the export income structure of the region. To the extent that this assumption holds, the results of this investigation are not seen to be biased. The results and interpretations of such in this study also suggest certain properties of the system being modeled which are difficult to verify because of the limiting factor of inadequate data. It should also be recognized that the estimated multipliers presented are gross estimates based
on data which do not reflect the limiting effect of taxation as a leakage.

An additional limitation which bears directly upon the research presented here is the accurate delineation of primary or export sectors. The sectors chosen here were taken as export by assumption for two reasons. First, the characteristic nature of the economic activity suggests that these sectors could be treated as export sectors. Second, the lack of more definitive export data for the Black Hills region requires that any delineation based on secondary sources be rather general. Thus, the total earnings figures were treated as all export induced. The effect of this limitation upon this research was to narrower the exogenous sectors to only those of agriculture, government, mining and wholesale-retail trade exports.

Unique Nature of the Method of this Study

The use of reduced form analysis to measure the separate impacts of exogenous export sectors on a regional economy has not been widely used in the past. The measures of the impact multipliers provided by this investigation are statistical estimates of parameters specified by economic theory. Direct comparison of these estimates with coefficients used as pedagogical tools, or estimates derived from much higher levels of aggregation is not recommended. Unless there is a significant correspondence between data definitions and method employed, direct comparison is not possible.
Complementary Research

The results of this study suggest several areas in which additional research and exploration may be fruitful. These areas are:

1. Research designed to provide more accurate and applicable regional accounts. Improvement of the economic base data would be beneficial in allowing a better delineation of export sectors and improved estimates of gross and net regional income.

2. The science of econometrics is continually expanding with the development of new techniques of estimation. At the present time there exist a few innovative techniques, still in the infancy stage, which may alleviate the difficulties associated with correlation among economic time series. It is suggested that as these methods become more fully developed, re-estimation of the parameters delineated in this study may provide further insights into the regional income process.

3. The results of this investigation suggest that certain sectors have relatively larger impacts on regional income than other sectors. This supports the economic hypothesis that the size of the various multipliers depend upon the marginal spending propensities of wage earners and profit recipients, and the relative distribution of income.
flowing to these sectors. This hypothesis, as suggested by economic theory and the findings of this analysis was not fully explored in this study. Research oriented toward delineating the differences in spending behavior between wage and profit recipients, as well as the distribution of income between these groups, may offer useful insights into the functioning of the regional economy studied. It is also suggested that similar analysis be undertaken for different regions of the state of South Dakota in order that the magnitudes of the impacts of the primary sectors across the state may be better understood.
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