# THE RELATIONSHIP BETWEEN CHANGING ECONOMIC STRUCTURE AND PERFORMANCE: Diversification, Diversity, Growth, Stability, and Distributional Impacts

by

Paul B. Siegel

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APPROVED:

Thomas G. Johnson, Co-Chair

Jeffrey R. Alwang, Co-Chair

Daniel B. Taylor

George W. Norton

Sandra S. Batie

Leonard A. Shabman

John M. Levy

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# ABSTRACT

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Paul B. Siegel

Thomas G. Johnson and Jeffrey R. Alwang, Co-Chairs

Department of Agricultural Economics

Key Words: Diversification, diversity, input-output, social accounts, structural change, decomposition of growth and stability, distributional impacts, rural economic development, regional planning model.

The major objectives of this study are to: (i) improve the understanding of what is meant by economic diversification and economic diversity, (ii) provide a comprehensive conceptual framework for region-specific analysis of the relationship between changing economic structure and economic performance measured in terms of the growth, stability, and distribution of income and employment, and (iii) construct an operational model of a regional economy that can be used to assess the impacts of alternative development strategies.

This study attempts to sort out the overlaps, contradictions, and gaps among the different economic and finance theories, and the different definitions and measures of economic diversification and diversity. The subject of economic diversification or diversity is addressed in the context of the question: "What is the relationship between a region's changing economic structure and performance?"

A structural model of a regional economy, an extended input-output model based on a social accounting matrix (SAM), serves as the foundation of the conceptual framework and operational model. The SAM-based input-

output model explicitly depicts the functional relationship between economic structure and performance. The region's demand, production technologies, and trade flows are included as part of economic structure. Economic performance is measured as the growth, stability, and distribution of regional income and employment, by occupation group. The structural model is used to analyze the relationship between economic structure and performance for a given time period, and to analyze changes over time. Growth, stability, and distributional impacts are considered simultaneously. By doing this, potential tradeoffs can be explicitly addressed.

To identify the structural sources of growth and stability, the SAM-based input-output model is decomposed at different points in time. By decomposing a SAM-based model it is possible to analyze structural sources of growth and stability in terms of both supply and demand factors. Alternative development strategies can be modelled using this conceptual framework.

The operational model quantifies the relationship between: (i) the anticipated growth and stability of exogenous final demands, and (ii) the anticipated growth, stability, and distribution of endogenous income and employment, by occupation group. The operational model focuses attention on the distributional impacts of changing economic structure and performance. The relationship between a region's social welfare, and the aggregation scheme and accounting stance used in the analysis of economic impacts are explicitly addressed. As such, there are explicit social welfare criteria for comparing and ranking alternative development strategies. The operational model presented in this study is well-suited to many popular input-output application packages.

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# CHAPTER 1 INTRODUCTION

"As a graduate student, as a young man trying to determine where I would spend my life, obviously oriented to public service, I concluded the whole question of economic development. That's why I chose to write my doctoral dissertation on that subject. The whole question of jobs, incomes, income distribution, fairness in the society, social justice; all of these issues are integrated and tied together by major trends that will shape America into the next century [Cisneros (1990), p.35]."

## 1.1 PROBLEM STATEMENT

The 1970's and 1980's have been characterized by significant changes in the economic structure and performance of many regions in the United States. Rapid changes in consumer demands, production technologies, and trade flows have contributed to this restructuring process. Many regions are facing crises caused by their inability to adjust to the changes in economic conditions.

To compound the problems faced by economically distressed regions, since the early 1980's, the policy of 'New Federalism' has led to a process of decentralization of economic and political responsibility. This makes regions more accountable for their own social welfare. As such, regions need improved conceptual and analytical capabilities to understand past and present economic developments, and to plan for the future.

The economic structure and performance of rural regions have been dramatically affected by the changing economic conditions [Johnson (1990); Johnston (1990)]. According to some recent studies on rural development [Belzer and Kroll (1986); Drabenstott et al. (1987); John et al. (1988); Rose et al. (1988); USDA (1990a); USDA (1990b)], the problems faced by many rural regions include:

(a) Secular decline and/or instability of income and employment from historically dominant sectors,

(b) An occupation mix concentrated in low-skill jobs characterized by low earnings,

(c) Unemployment and/or underemployment of immobile labor and out-migration of mobile labor,

(d) New economic activity which requires the in-migration of higher-skilled labor, while most job growth for residents is in low-paying service occupations, and

(e) Uneven distributional impacts of the restructuring process among individuals, households, occupations, and sectors.

All of the studies cited above suggest economic diversification as a means for addressing the economic problems faced by rural regions. Below are some selected excerpts:

> "Easing the transition from narrower traditional economic bases to new, more diversified rural economies appears appropriate as the major objective of a federal rural development policy. A diversified economy is no guarantee against economic stress, but diversification helps buffer the wide economic swing many rural areas have experienced in the 1980's [Drabenstott et al. (1987), p.51]."

> "... diversification is an important economic development option when an area is dominated by a seasonally or cyclically fluctuating industry, or when the dominant industry is facing structural changes that will lead to reduced employment (Belzer and Kroll (1986), p.19]."

> "What are states doing to promote economic development in rural America? How can states support community efforts for economic diversification and growth [John et al. (1988), p.4]?"

> "... diversification of rural economies and retention of more value-added emanating from resources through further processing stages would help reduce distributional inequities in the shorter term [Rose et al. (1988), p.7]."

> "Only a fully diversified economy will create a new life in rural communities throughout America [USDA (1990a), p.2]."

> "Rural areas are faced with diversifying their economies or dying from attrition [USDA (1990b), p.vii]."

Implicit in these excerpts is the assumption that economic diversification (i.e., change in economic structure) can lead to favorable changes in the growth, stability, and distribution of income and employment (i.e., changes in performance). In fact, many rural regions have contemplated or initiated economic diversification policies expecting improved performance.

At the same time, there are recent studies on rural development that challenge the hypothesized positive relationships between economic diversification and performance [Killian and Hady (1988); Newman (1987); Painton (1991); Smith and Gibson (1988); Smith and Weber (1984)].

In the report Coping With Change: Rural America in Transition, whose results were presented in testimony to a Congressional Committee, one study concludes that evidence from rural Appalachia:

> "led to the questioning of some of the most deeply held beliefs about the economic performance of regions. A look at the data makes it clear that satisfactory economic performance cannot be assured through diversification. Some diversified counties in the Appalachian Region have done poorly, some specialized counties have done relatively well [Newman (1987), p.84]."

Other studies claim that:

> "a diversified economy is a part of rural development; but it is a site and industry specific issue, not a blanket condition that will improve conditions throughout rural America [Painton (1991), p.12]."

> "Indiscriminate diversification will not bring economic stability [Smith and Gibson (1988), p.193].

> "Diversification is often viewed uncritically as the most appropriate strategy for achieving growth and stability... however, the results in this report give a clear indication that trade-offs do exist... [Smith and Weber (1984), p.1, and p.45]."

Based on all of these studies, it can be observed that economic diversification is a major subject of concern in the formulation of rural development policies in the United States. Due to disagreements about the relationship between the process of economic diversification and performance, it can be concluded that the subject of economic diversification requires additional attention.

## 1.2 LACK OF GUIDANCE FROM PAST STUDIES

To seek guidance on the subject of economic diversification a review of the regional science literature is undertaken. During the past sixty years there have been numerous attempts to develop a meaningful definition and measure of economic diversification, and to empirically test hypothesized relationships between economic diversification and performance. In the regional science literature, the meaning of economic diversification, its measurement, and its relationship to economic performance is ambiguous, confusing, and in some cases conflicting. This hinders a systematic analysis of the relationship between economic diversification and performance.

Past studies do not provide an appropriate conceptual or analytical framework to address the economic problems faced by rural regions. They tend to: (i) use imprecise definitions and measures of economic diversification, (ii) use definitions and measures based on a static concept of economic structure, (iii) narrowly focus on economic stability as a measure of economic performance, (iv) ignore changes in a region's population, (v) focus on interregional comparisons, and (vi) lack a model of a regional economy for analyzing the relationship between changing economic structure and performance.

In most studies, economic diversity is defined and measured in terms of a region's economic balance at a point in time, using various 'goodness-of-fit' measures that calculate deviations from some standard. In most cases the standards are benchmarks that do not provide practical guidelines for the planning of diversification policies.

Actually, past studies define and measure the state of economic diversity, which is a static concept; not the process of economic diversification, which is a dynamic concept. This distinction is not always made clear. Part of the confusion in the literature results from the focus on diversity, rather than the process of diversification, and the imprecise usage of these terms. Some of the confusion can also be attributed to the fact that different economic and finance theories use somewhat different concepts of diversification.

Most of the attention in the literature focuses on hypothesized relationships between diversity and stability. The relationship between economic diversity and other measures of economic performance, such as growth and distribution, are ignored. However, even in this narrow context, there is inconclusive empirical evidence about the relationship between economic diversity and stability.

The narrow focus on stability may be justified if growth rates are satisfactory, or if there is a strong positive correlation between growth, stability, and distributional impacts. However, as noted in Section 1.1, many rural regions have unsatisfactory growth rates, and the relationship between growth, stability, and distributional impacts is an empirical question that should be addressed on a sector- and region-specific basis.

Past studies have not considered the changes in a region's demographic composition that take place during the process of economic diversification. As mentioned in Section 1.1, the populations in rural regions are changing due to in- and out-migration. Population changes can have an important effect on the growth, stability, and distribution of a region's income and employment.

The measures of diversity and stability used in the literature are region-wide measures. For hypothesis testing based on a cross-sectional analysis, the use of region-wide measures permits interregional comparisons of relationships between diversity and stability. However, by construction, these studies ignore distributional impacts within a region. This may be justified if none of the economic conditions of the region's individuals, households, occupations, or sectors deteriorate over time, or if they all deteriorate at the same rate. However, as noted in Section 1.1, the restructuring process has led to uneven distributional impacts in many rural regions.

The measures of economic diversity used in the literature are also measures of economic performance, the outcomes of an economic process. The studies generally purport to measure the relationship between structure and performance using these measures of diversity. The most widely used measures of economic diversity, the sectoral distribution of income and employment, are dependent on economic structure. That is, economic structure and performance are not measured independently. Independent measures of economic structure and performance are required to understand their functional relationship, and to model their relationship.

The economic structure of most rural regions is undergoing change and will continue to change. Hence, it is important to distinguish between structural change that leads to improvements in economic performance versus structural change that leads to deteriorations. For policy-relevant research on economic diversification, a model of a regional economy is required in order to provide a theoretical basis for assumptions about the relationship between changing economic structure and performance.

A policy-relevant framework to analyze the relationship between changing economic structure and performance is needed. To be policy-relevant: (i) the definitions and measures of economic diversification and diversity should provide practical guidelines for changing economic structure to achieve goals of performance, (ii) the functional relationship between changing economic structure and performance should be established, and (iii) a model of the relationship between changing economic structure and performance is needed. Based on (i) to (iii) the impacts of alternative development strategies could be evaluated.

## 1.3 OBJECTIVES

The major objectives of this study are to:

(i) improve the understanding of what is meant by economic diversification and economic diversity,

(ii) provide a comprehensive conceptual framework for region-specific analysis of the relationship between changing economic structure and economic performance measured in terms of the growth, stability, and distribution of income and employment,

(iii) construct an operational model of a regional economy that can be used to assess the impacts of alternative development strategies,

and

(iv) lay the foundation for future empirical studies.

The following passage embodies many of the issues that will be addressed in this study:

> "Diversification ... is not synonymous with development. Economic development ideally involves both rapid and steady growth, whether in terms of incomes or employment. However, rapid growth and stable growth are not always compatible... Specialization per se is not necessarily an undesirable characteristic of local economies... Areas specializing in high-growth industries may grow considerably faster than areas with a diverse mixture of high- and slow-growth industries, but may pay for it by being more vulnerable to outside economic and political forces. Thus, overall economic performance generally depends on both the diversity of the local industrial structure and the characteristics of the area's dominant industries [Killian and Hady (1988), p.2]."

This study will clarify issues raised in this passage, and translate its message into a policy-relevant conceptual framework and operational model.

## 1.4 PROCEDURES

The conceptual framework and operational model presented in this study provide a new approach for analyzing regional economic diversification. According to the approach taken in this study, the 'ideal' balance of economic structure is determined by examining the relationship between economic structure and performance, where elements of performance comprise a region's social welfare.

The process of economic diversification is addressed in the context of the question: "What is the relationship between a region's changing economic structure and performance?" This is a dynamic concept of economic diversification. The guidance for this approach comes from the development economics literature, where diversification is defined as the process of economic transformation.

In this study, comprehensive measures of a region's economic structure and performance are used. The model of a regional economy that serves as the basis of the conceptual framework and operational model is an extended input-output model. This is a structural model of a regional economy. Input-output accounts are combined with social accounts and accounts of trade flows into a social accounting matrix (SAM). A SAM records the circular flow of a region's economic activity. It can be used to analyze what a region makes and consumes (sectoral mix), how it makes and trades it (intersectoral linkages), who does it (occupational mix), and how value-added is distributed.

The SAM-based model can be used to analyze the relationship between economic structure and performance for a given time period, and to analyze changes over time. A 'probabalistic' input-output model is introduced to measure the expected growth and stability of regional economic performance. To identify the structural sources of growth and stability, this model is decomposed using standard decomposition techniques. These decomposition techniques are extended and adapted for use in this study.

The region's demand, production technologies, and trade flows are included as part of economic structure. Economic performance is measured as the growth, stability, and distribution of regional income and employment, by occupation group. It is assumed that these elements of economic performance help determine a region's social welfare. Since growth, stability, and distributional impacts are considered simultaneously, potential tradeoffs are explicitly addressed.

Using the conceptual framework, an operational model is constructed. The operational model is based on the perspective of a planner who is evaluating the relationship between economic structure in a base period, and anticipated performance. The operational model quantifies the relationship between the growth and stability of exogenous final demands, and the endogenous growth, stability, and distribution of regional income and employment. Based on different assumptions about base period economic structure, and different assumptions about the growth and stability of exogenous final demands, the impacts of alternative development strategies can be evaluated. The model can also be used to project labor demands. The operational model is well-suited for applications using 'packaged' input-output models.

## 1.5 ORGANIZATION OF THIS STUDY

The remainder of this study is organized as follows. Chapter 2 reviews the literature on economic diversification, with a focus on the regional science literature. Chapter 3 presents a conceptual framework for analyzing the relationship between changing economic structure and performance, and for formulating alternative development strategies. Chapter 4 presents an operational model that can be used to assess the impacts of alternative development strategies. In Chapter 5 the summary and conclusions are presented.

# CHAPTER 2 LITERATURE REVIEW

"In recent years the emphasis on the need for diversification has assumed, in a few areas, some of the aspects of a search for a panacea for the solution of all local economic problems. In view of the present importance of diversification policy in the country an understanding of the nature and effects of industrial diversification is essential to effective industrial planning...[However] The term diversification has been used in so many contexts in the past that more precise definition and measurement is needed [Rodgers (1957), p.16]."

"If the separate meanings of the same word are closely related, overlapping, or otherwise ambiguous so that the context cannot be relied upon to indicate which meaning is intended, the writer or speaker has a moral duty, I would say, to state what he means. Often he can do so quite easily and briefly, perhaps with the first use of the word or phrase in question, provided he uses it consistently. To use it sometimes in one meaning and sometimes in a different meaning without due warning and clarification, is inconsiderate and mischievous. A thoughtful scholar will either look for less ambiguous terms as substitutes or will use adequate modifiers to remove the possibility of misunderstanding or doubt of his audience [Machlup (1958), p.280]."

## 2.1 DIVERSIFICATION, DIVERSITY, AND ECONOMIC BALANCE

The terms economic diversification, balance, and structure are inexorably linked:

> "Regional economic balance, or, in somewhat more definite terms, diversification, has for a long time been viewed as a 'healthy' structural feature worth striving for. The grounds for this view, however, have not been clearly articulated [Hoover and Giarratani (1984), p.371]."

According to this passage, diversification is defined as a balanced economic structure. It is implied that a region with a balanced economic structure will be better situated to achieve performance goals. However, the meaning of a balanced economic structure, and the relationship between a balanced economic structure and performance are unclear. This passage epitomizes some of the confusion that besets the subject of regional economic diversification.

One reason for the confusion is that the term diversification has multiple definitions and usages. The following definitions are contained in the Funk and Wagnalls Standard Dictionary (1980):

Diversity, n. 1. Unlikeness; difference. 2. Variety.

Diverse, adj. 1. Different; not alike. 2. Varied; diversified.

Diversify, v. diversified, diversifying. 1. To make more diverse; vary. 2. To make (investments) among different types of securities so as to minimize risk. --diversification, n.

Specialize, v. specialized, specializing. 1. To concentrate on one particular activity or subject. 2. Biology: To take on a special form; adapt. --specialization, n.

As can be observed from these dictionary definitions, the noun diversity and the adjective diverse refer to the <u>state</u> of unlikeness, difference, and variety. The verb diversify and the noun diversification refer to: (i) the <u>process</u> of making things more unlike, different, and varied, and (ii) the <u>process</u> of selecting assets to minimize risk (i.e., the concept of portfolio theory).

In the context of a regional economy, the terms diversity and diverse refer to a balanced economic structure without regard to performance goals. In contrast, the terms diversify and diversification describe the process of changing the balance of economic structure, with or without reference to performance goals. Neither diversity nor diversification is considered a goal, in and of itself.

The terms diversity and diverse refer to a static and positive concept of regional economic structure. The term diversify, which refers to making something more diverse via the process of diversification, is a dynamic concept of regional economic structure that can be either positive or normative.

As will be shown in Section 2.6, most of the definitions and measures of economic diversity and diversification in the regional science literature are actually measures of diversity, and "not diversification which should be considered the process that changes the level of diversity [Malizia (1990), p.34]." Unfortunately, "Some research makes no distinction between diversity and diversification, as if these terms were interchangeable [Malizia and Ke (1991), p.7]."

There are also different definitions of specialization. The first definition, which is related to the concept of concentration, seems to be the opposite of the concept of diversity. The second definition of specialization, which is used in biological sciences, implies that there is some goal which leads an organism to "take on a special form; adapt". In the context of a regional economy, the first definition of specialization is a static and positive concept associated with variety or lack of variety. The second definition is a normative and dynamic concept related to the process of striving towards some performance goals.

Below is a passage (emphasis is added) from the textbook, <u>An Introduction to Regional Economics</u> [Hoover and Giarratani (1984)]. This passage is indicative of the overlaps and ambiguities in the usage of the terms defined above:

> It "is sometimes assumed that a region with a **diversified** structure (many different kinds of activities and an absence of strong **specialization**) is necessarily less vulnerable to cyclical swings of general business conditions and demand... It is a different story, however, when we consider stability and other desirable attributes over a longer time period. In time, any of a region's activities will suffer arrested growth and perhaps decline or even extinction, either because the product itself becomes obsolete ... or because the region loses out competitively ... If a region is narrowly **specialized**, such a loss can be, at

least temporarily, disastrous; in a **diversified** region, it is unlikely that a major proportion of total activity will suffer at any one time. Equally significant is the fact that a narrowly **specialized** region is likely to show less resilience in recovering its stride by developing new activities to take the place of those lost. This attribute of resilience is an extremely important aspect of regional economic health. It depends to a large extent on **diversification**, since **diversity** of employment develops a wide variety of skills and interests in the labor force and also among business entrepreneurs, bankers, and investors, and a wider array of supporting local business services and institutions [Hoover and Giarratani (1984), p.372]."

It would seem that economic diversification is the ultimate hedge, that is, a diversified regional economy is expected to achieve both stability-oriented and growth-oriented goals. Economic diversification can lower instability by creating a wider base of economic activity, and enhance growth by adding sectors with positive growth trends. Furthermore, there are apparently no tradeoffs between economic growth and stability, and no gains from specialization. If this is indeed the case, it is no wonder that economic diversification is often hailed as the "panacea for the solution of all local economic problems [Rodgers, (1957), p.16]."

Since 1930, many regional scientists have proposed different definitions and measures of economic diversification (actually diversity) that are related to the dictionary definitions discussed above. In addition to the dictionary definitions, there is a definition of the term diversification used by development economists. This definition, or usage, of the term diversification is associated with the structural change of an economy.

To development economists, diversification is the process of structural transformation as resources are shifted out of primary (natural resource-based) sectors into secondary (manufacturing) and tertiary (service) sectors [Barghouti et al. (1990); Basu (1990)]. This change in economic structure, which is driven by changes in demand, production technologies, and trade flows, actually defines modern economic development [Syrquin and Chenery (1989), p.1].

The underlying assumption of the structural transformation process is that economic structure should be 'balanced' towards certain sectors and against others. The imbalance between growing and declining sectors facilitates the process of economic development [Harris (1989); Scitovsky (1989)]. Clearly, this concept of regional economic diversification, which is discussed in Section 2.6.6, is dynamic and normative.

The various definitions of diversity and diversification as economic balance reflect different concepts of economic structure, and focus attention on different relationships between economic structure and performance. This can be summarized as follows:

(a) Terms - Diversity, diverse, diversify, diversification.
Economic Balance - Variety of economic activity.
Relationship to Performance - None.

(b) Terms - Diversify, diversification.
Economic Balance - Stability of economic activity.
Relationship to Performance - Stability.

(c) Term - Diversification.
Economic Balance - Transformation of economic activity.
Relationship to Performance - Development.

Hence, there are three different usages of the term diversification. This distinction is not always made clear. A recent example is the Presidential Address to the Southern Agricultural Economics Association in 1991.

> "Diversification is the central policy in many development efforts, both international and domestic. Its purpose is to improve incomes by reducing vulnerability to production or market conditions for a particular enterprise. Schuh and Barghouti (1988) suggest a need to divert land, labor, and capital toward new enterprises in the wake of major production innovations for a traditional crop... The biggest policy challenge they argue, is to shift labor out of agriculture to new income possibilities [Libby (1991), p.2]."

Libby (1991) combines definitions (b) and (c) of diversification into a single concept. This overlap can have important consequences if "diversification is the central policy in many development efforts, both international and domestic."

In this study, the conceptual framework and operational model presented in Chapters 3 and 4 are based on the concept of diversification as a process of structural change. However, the concepts of diversity as variety, and diversification as a process of stabilization are also used, when appropriate.

The overlap and confusion that result from the multiple definitions of diversification, and the close linguistic association between the terms diversity, diverse, diversify, and diversification have also been reflected in the different measures of economic diversity and diversification (as will be shown in Section 2.6).

## 2.2 HYPOTHESIZED RELATIONSHIPS BETWEEN ECONOMIC DIVERSITY AND STABILITY

Research on the relationship between economic diversity and stability was stimulated by the economic instability that characterized the 1920's and 1930's. Research by McLaughlin (1930) and by Tress (1938) are often cited as the earliest attempts to construct measures of economic diversity and to test the hypothesized positive relationship between economic diversity and stability. These studies provided a conceptual and empirical foundation for all ensuing studies in the regional science literature.

McLaughlin (1930) and Tress (1938) observe that, in the U.S. and in the U.K., respectively, many regions that lacked diversity in sectoral and/or occupational composition were vulnerable to instability during the 1920's and 1930's. In addition, they observe that some of the specialized regions were also characterized by economic activity concentrated in sectors beset by secular decline (due to declining demand or changing production technologies).

In the study "Industrial Diversification in American Cities", McLaughlin [(1930), p.133] claims that:

> "a community can stabilize its economic life in so far as it can find industries the fluctuations of which complement [sic., counter] the fluctuations of existing industries, and to the extent that these desired lines of activity can be introduced. As a rule, since no two businesses have exactly the same seasonal and cyclical swings, the more types of production and trade are represented, the more stable will be the community's business."

McLaughlin (1930) hypothesizes that a region can stabilize its economy if it can find the 'ideal' balance of sectors. Over the past sixty years numerous regional scientists have attempted to construct the ideal measure of the ideal balance of sectors. It was thought that such a measure could then be used to help guide industrial targeting and recruitment strategies towards greater region-wide economic stability (i.e., that such a measure could be used for policy-relevant analysis).

A sectoral aggregation scheme groups similar production-oriented economic activities. A sector is an aggregation of firms with similar inputs (including labor) and outputs. Previous studies in the regional science literature on economic diversification and diversity are based on sectoral aggregations of economic activity. Hence most of the definitions and measures presented in this chapter are in terms of sectoral aggregation schemes. This does not preclude other aggregation schemes, as will be shown in Chapters 3 and 4.

Over the past sixty years, four hypothesized relationships between economic diversity and stability have been proposed and tested in the regional science literature: (i) the sectoral-diversity hypothesis, (ii) the sectoral-mix hypothesis, (iii) the regional-national sectoral composition hypothesis, and (iv) the region-size hypothesis. Below is a brief review of these hypothesized relationships. A more detailed review of this literature can be found in Kort (1979; 1991).

### 2.2.1 Sectoral-Diversity Hypothesis

Following McLaughlin (1930) and Tress (1938), it has been hypothesized that there is a positive correlation between economic diversity and stability. According to the sectoral-diversity hypothesis, the more diverse the economic activity of a region, the more stable its economic performance. This hypothesis, which is conceptually related to portfolio theory (defined in Section 2.6.2), has an intuitive appeal because of the inherent logic that a region dependent on a single sector (or a very narrow base of sectors) is more likely to be vulnerable to cyclical fluctuations.

To test this hypothesized relationship, various measures of sectoral concentration and/or measures derived from portfolio theory have been used as measures of economic diversity (discussed in Section 2.6.2) The sectoral diversity hypothesis has been the most widely tested hypothesis in the literature.

### 2.2.2 Sectoral-Mix Hypothesis

According to the sectoral-mix hypothesis, regional differences in economic stability can be explained by a region's mix of stable and unstable sectors. This hypothesis is based on the widely accepted view that certain types of sectors such as durable goods are more unstable than other types of sectors. To test this relationship, a region's share of stable or unstable sectors has been used as a measure of economic diversity (discussed in Sections 2.6.3 and 2.6.4). The sectoral-mix hypothesis has also been widely tested in the literature.

### 2.2.3 Regional-National Sectoral Composition Hypothesis

According to the regional-national sectoral composition hypothesis, a region's economic structure should be measured relative to the nation's (i.e., the average of all regions). It is hypothesized that the more similar a region's sectoral composition is to that of the nation's, the more stable it should be relative to other regions.

Various measures of economic diversity have been used that compare a region's economic structure to that of the nation. The similarity between regional and national economic structure is a popular definition of economic diversity. The measures of economic diversity based on this definition are widely used (discussed in Sections 2.6.3 and 2.6.4). However, the hypothesized relationship has not been widely tested in the literature.

### 2.2.4 Region-Size Hypothesis

The region-size hypothesis assumes that a region's economic structure is a function of its population size. It is assumed that there are more intersectoral production and consumption linkages and fewer trade leakages for regions with larger populations. Although greater linkages and lower leakages can potentially contribute to economic instability, the greater diversity of economic activity associated with a larger region is assumed to counter some of this potential for instability. Hence, according to the region-size hypothesis there should be a positive relationship between region size and economic stability. In this case, the 'measure' of economic diversity is simply a region's population size (discussed in Section 2.6.6).

This hypothesis has not been widely tested in the literature, but it is widely accepted as a 'stylized fact'. Actually, some empirical tests of the other hypotheses have used a region's population size as a means for adjusting for regional biases (e.g., to adjust for heteroskedasticity) [Kort (1981); Brewer and Moomaw (1985)].

## 2.3 EMPIRICALLY TESTING HYPOTHESIZED RELATIONSHIPS BETWEEN ECONOMIC DIVERSITY AND STABILITY

Although McLaughlin (1930) and Tress (1938), and most other studies after them, did not find unambiguous empirical support for the hypothesized positive relationship between different definitions or measures of economic diversity and stability, this issue has been the focus of continuing attention in the regional science literature. In a recent review of this literature, it was noted that:

> "Countless regional scientists made their mark on the regional literature by reassessing the issue of economic diversity and regional economic instability [Kort (1991), p.1)]."

The hypotheses described in Section 2.2 have been tested using region-wide measures of economic diversity and stability (to be discussed in Sections 2.4 and 2.6). The measure of diversity used depends on the theory to be tested. Some studies have used simple rankings of regions according to their respective measures of economic diversity and stability in an attempt to uncover some systematic relationship. Other studies have used regression techniques to test the following functional relationship:

(2.1)

$$REI_i = f(RED_i) ,$$

where $REI_i$ is a measure of economic instability for ith region, and $RED_i$ is an appropriate measure of economic diversity for the ith region. Assuming a linear relationship between REI and RED, ordinary least squares regressions have been used to estimate the following equation:

(2.2)

$$REI_i = \alpha_i + \beta_i RED_i + u_i .$$

The sign and t-statistic of $\beta_i$ are examined in order to test whether the respective hypothesis is statistically significant. In some cases additional explanatory variables are added to equation (2.2), including other measures of RED (e.g., region-size). Some studies have compared the explanatory power of alternative measures of economic diversity. Researchers finding the expected signs, higher t-statistics, and higher $R^2$ have claimed that one measure of economic diversity is superior to the others.

However, this approach to economic diversification does not necessarily provide policy-relevant information on the relationship between changing economic structure and performance. To be policy-relevant: (i) the definitions and measures of economic diversity should provide practical guidelines for changing economic structure to achieve goals of economic performance, (ii) the functional relationship between changing economic structure and performance should be established, and (iii) a model of the relationship between changing economic structure and performance should is needed. Then, based on (i) to (iii), the impacts of alternative development strategies can be evaluated. In the regional science literature, most of the focus has been on (i) and (ii), however, as pointed out in this chapter, with limited success.

## 2.4 SOME MEASURES OF STABILITY AND DIVERSITY

As can be observed from equations (2.1) and (2.2), the definition and measurement of economic stability are critical to understanding the relationship between economic diversity and stability. Also, as will be shown, the definition and measurement of economic stability is critical to understanding the relationship between economic diversity and growth, and between economic diversity and distributional impacts.

### 2.4.1 Measures of Economic Stability

Open market economies are characterized by business cycles, which are "a wavelike movement in the general level of economic activity that takes place over time [Peterson, (1988), p.696]." The wavelike movement results from alternating periods of expansion and contraction around a long-term trend [Sommers (1988), p.89]. There are various definitions and measures of the economic instability associated with a business cycle. Popular measures of business cycles include the amplitude from a cycle's peak-to-trough, the duration from peak-to-peak or trough-to-trough, the duration of an expansion or contraction, and the frequency of cycles [Peterson (1988), p.696].

Economic instability can also be defined and measured as periodic deviations from a long-term trend. Hence, time-series economic data can be decomposed into an oscillating cyclical component, a growth trend component, and a random error component [Sommers (1988), p.89].

In the regional science literature, the measure of REI that has been most widely used to estimate equation (2.2) was introduced by Siegel (1966):

(2.3)

$$REI_i = \left[\frac{\sum_{t=1}^{T_*} ((X_{it} - \hat{X}_i) / \bar{X}_i)^2}{(T_* - 2)}\right]^{1/2},$$

where:

$X_{it}$ = the growth rate (or level) of economic performance for the ith region in time period t,

$\hat{X}_{it}$ = the trend growth rate (or level) of economic performance for the ith region in time period t, and

$\bar{X}_i$ = the mean growth rate (or level) of economic performance for the ith region over $T_*$ time periods.

This measure defines instability as squared deviations from the trend, normalized by the mean. The normalized variance is then converted into a standard deviation by taking its square root. This 'coefficient of variation' may be roughly interpreted as the standard deviation of the fluctuations expressed as a percentage of the mean level for the period under consideration [Jackson (1984), p.106]. Using this measure of REI it is possible to make comparisons of economic stability that are based on a common metric.

Hence, measures of REI are well-suited for interregional comparisons of economic instability. However, when REI is used as a region-wide measure of economic instability, the distributional impacts of cyclical fluctuations on sectors and individuals within a region are ignored. This does not imply that intraregional distributional impacts should be included in interregional comparisons. It is only a warning that measures appropriate for interregional comparisons may not be appropriate for region-specific analysis.

To construct REI, different measures of economic performance have been used (e.g., income, employment, or unemployment), and different growth trends have been used (e.g., linear, or quadratic). Also, in some studies REI has been normalized using the time-variant trend, $\hat{X}_{it}$, instead of the mean, $\bar{X}_i$.

Economic instability is presumed to be an increasing function of deviations from the trend. This measure of economic instability is very sensitive to the definition and measurement of the trend. When constructing a measure of instability based on deviations from a systematic trend, it is implicitly assumed that the trend itself is not a source of instability [Ali et al. (1991), p.9]. It is assumed that the growth trend is expected by regional planners, and by economic agents (e.g., individuals, firms, and sectors). In most studies, the selection of a particular growth trend has tended to be *ad hoc* or, at least, not based on a well-specified statistical model. Hence, there may be a divergence between the 'actual' and 'estimated' expectations, and perceptions of what is stable and unstable. An accurate estimation of expectations (and deviations from expectation) will have important implications for the measurement of expected growth and stability, and, in turn, the comparison and ranking of alternative development strategies.

The growth trend itself can provide valuable information about economic performance. The growth trend describes the direction and magnitude of growth, which are important measures of economic performance. Unfortunately, past studies that analyzed the relationship between economic diversity and economic stability using REI as a measure of stability have ignored the growth trend. Doing this, stable decline and stable growth are indistinguishable.

### 2.4.2 Goodness-of-Fit Measures of Economic Diversity

As will be observed in Section 2.6, some of the measures of economic diversity are conceptually similar to the measure of economic instability presented in equation (2.3). The common feature between the measure of REI and most of the measures of RED is the that they are region-wide measures of 'goodness of fit', which calculate the deviation between an expected value and an observed value. These measures of RED are static and positive measures of diversity, with diversity measured using 'chi-square' types of distribution [Fomby and Hirschberg (1989), p.18].

A chi-square distribution can be expressed as:

(2.4)

$$\chi^2 = \sum \frac{(X - E[X])^2}{E[X]} ,$$

where X is the observed value and E[X] is the expected value. In the case of measures of economic diversity, E[X] is the standard by which the 'ideal' economic balance is compared. The chi-square distribution is a normalized squared deviation, which can be used for interregional comparisons.

All goodness-of-fit measures are extremely sensitive to: (i) the standard used as a basis for calculating deviations, and (ii) the level of aggregation used to organize the data. Since the goodness-of-fit measure presented in equation (2.4) calculates squared deviations, it weights larger deviations greater than smaller deviations. However, the contribution of any individual sector's deviation has an identical weight for an identical deviation. Hence, the relative contribution of small and large sectors is not differentiated. This shortcoming can be addressed by multiplying each sector's normalized squared deviation by its sectoral share. As will be shown in Section 2.6.6.2, a widely used measure of diversification (which is really a measure of diversity), the 'portfolio variance', can also be considered a $\chi^2$ measure.

Since most measures of regional economic diversity are goodness-of-fit measures based on different standards, it is clear why there is some confusion over what is meant by economic diversity. Regional economic diversity will depend on which standard is being used. Grossberg (1982) and Jackson (1984) demonstrate how, depending on the particular standard used, a region can be defined as diverse, or as specialized.

## 2.5 SOME CONCEPTUAL SHORTCOMINGS OF PAST STUDIES

In Sections 2.2, 2.3, and 2.4 some of the conceptual shortcomings of previous studies in the regional science literature were pointed out. Additional shortcomings are pointed out in this section and in the next section.

McLaughlin (1930) and Tress (1938) observe that some regions are characterized by both economic instability and economic decline. If economic instability and decline, or economic growth and stability are positively correlated, then it may be possible to focus attention on either stability or growth. The relationships between economic growth, stability, and distributional impacts of income and employment are empirical issues that require more attention. If there are tradeoffs between these different measures of performance, which is often assumed to be the case [Shaffer (1989), p.84], then the measures should be considered simultaneously. This is the approach taken in Chapters 3 and 4.

Since all empirical testing of the relationship between economic diversity and stability has been based on interregional comparisons, region-wide measures of stability and diversity were used. When using region-wide measures, the economic instability faced by individuals, households, firms, and sectors are all ignored. Considering that the sectoral-diversity, sectoral-mix, and region-size hypotheses are implicitly or explicitly based on identifying sectors with counter-cyclical fluctuations, there are clearly uneven distributional impacts, at least between sectors. In Chapters 3 and 4, a region-specific approach to economic diversification is adopted, so that region-specific economic factors can be depicted and distributional impacts within a region can be measured.

Most of the studies measure economic diversity using the distribution of income or employment among sectors. That is, a region's economic structure is measured using the sectoral distribution of regional income or employment. However, as will be demonstrated in Chapters 3 and 4, the sectoral distribution of regional income or employment can also be considered measures of economic performance. Although the sectoral distribution of a region's income and employment do describe a region's economic structure, they are a function of the region's economic structure. This issue of causality is important, and studies which ignore the process that generates regional income and employment have limited policy-relevance.

In fairness to past studies that use the sectoral distribution of regional income or employment as a measure of economic diversification, these data (notably employment by sector) are readily available on a county or city basis. Hence, data considerations may have overruled theoretical considerations for some researchers. In this study, a comprehensive conceptual framework and operational model are presented, but there are no empirical applications. An objective of this study is to lay the foundation for future empirical work.

Tress (1938) hypothesizes that the stabilizing effect of economic diversity is two-fold: (i) it decreases the risk of region-wide economic instability by offsetting increases and decreases in exogenous demand, and (ii) it increases the opportunity for intersectoral transference (i.e., movement) of resources, notably labor. The first case was addressed by McLaughlin (1930) (recall the quote in Section 2.2). According to Tress (1938) the:

> "second case for local diversity calls for further comment as it is obvious that, if facilities for labor transference are taken into account, local diversity ceases to be mere absence of over-great specialization and becomes something positive. A diversification policy on this basis would ... require a much greater knowledge of both present relationships between industries, as regards alternative employment, and of their future prospects [Tress (1938), p.142]."

In most of the regional science literature, attention has focused on the relationship between sectoral diversity and economic stability and not the relationship between sectoral diversity and the intersectoral mobility of labor. Intersectoral movement of labor is implicitly or explicitly assumed to take place when different sectors are experiencing counter-cyclical fluctuations in demand. However, studies by Jackson (1984), Smith (1990), and Thompson and Thompson (1987) emphasize the need for explicitly considering the intersectoral mobility of labor. Such an analysis requires information on occupation-sector relationships so that sectoral labor demands can be measured for each occupation group. This approach is adopted for the operational model presented in Chapter 4.

Finally, Tress [(1938), p.144] warned against using region-wide measures of economic diversity to depict a region's economic structure because:

> "It would be difficult to construct an index which covered all the implications of diversity outlined above, even if those implications were completely explicit."

This warning was recently restated by Jackson, Hewings, and Sonis [(1990), p.216]:

> "...too much work and theory at the regional level has operated with scalar or vector conceptions of regional economic structure... This is very unfortunate for two reasons. First we have gained very little understanding of how changes in the vector representations of economic activity have created changes in the underlying matrix of interactions among these activities. Secondly, changes in these interactions may prove to be the most useful indicators of the strength, the growth dynamics, or the development path of an economy."

Despite these warnings researchers have continued to construct scalar and vector measures of economic diversity, which are ostensibly measures of a region's economic structure. In contrast, in Chapters 3 and 4 comprehensive measures of economic structure are used, based on a matrix of economic interactions.

## 2.6 DIVERSIFICATION, DIVERSITY, AND THEORY

The focus of the regional science literature on the relationship between economic diversity and stability is very limited in scope. This narrow focus should be considered in the context of the following: (i) stability is not the region's only goal of economic performance, and (ii) according to different economic and finance theories, economic diversification or diversity may lead to different goals of economic performance.

The following passage, which introduces a study of the relationship between economic diversity and stability, acknowledges the narrow focus on stability as a goal of economic performance:

> "The goal of regional stability (where the act of stabilizing a region is defined as minimizing the deviations from some regional economic aggregate from its long-term secular trend), while somewhat less important than the goals of increased per capita income levels, improved distribution of income, and strong economic growth, is nevertheless a desirable economic objective [Kort (1979), p.2]."

The narrow focus on stability should be considered in the context of the wide variety of definitions of economic diversification that can be found in economic and finance theory. The theories address different dimensions of economic performance, including growth, stability, distribution, and the process of economic development.

The concepts of diversification and specialization are important components of trade theory, portfolio theory, economic base theory, regional business cycle theory, location theory, and economic development theory. The following sections review different definitions and measures of economic diversification (and diversity) that are associated with these theories.

### 2.6.1 Trade Theory

According to trade theory, exchange is based on the diversity of economic agents in terms of endowments and preferences, and their respective specialization in production according to comparative advantage. Regional economic specialization based on comparative advantage occurs because regions, like individuals, have different 'endowments' and 'preferences'. Regional endowments vary with respect to: (i) natural resources (e.g., soil, climate, and mineral deposits), (ii) human resources (e.g., occupational mix of the labor force, educational levels of residents, and demographic mix of residents), (iii) spatial resources (e.g., proximity to population centers, and access to harbors or airports, (iv) infrastructural resources (e.g., transportation and communication facilities), and (v) technological resources (e.g., available technologies).

Regional preferences are expressed through public policies such as industrial targeting and recruitment activities, zoning ordinances, tax rates, environmental regulations, educational facilities, and labor laws. According to trade theory, economic specialization based on comparative advantage, not economic diversification, should lead to economic growth.

Information on a region's comparative advantage is often used in industrial targeting studies. Shift-share analysis is widely applied by regional scientists for *ex post* assessments of regional comparative advantage. Shift-share analysis is a decomposition technique that identifies proximate sources of temporal change in measures of economic performance or structure. It is assumed that changes in economic aggregates can be decomposed into: (i) national, (ii) sectoral, and (iii) regional components.

Various measures of economic aggregates can be decomposed using shift-share analysis. Shift-share analysis is usually used to decompose the growth of sectoral employment or income. Some studies have used extensions of shift-share analysis to decompose the stability of sectoral employment [Riefler (1986)], and changes in economic structure (input-output and regional purchase coefficients) [Jensen, West et al. (1991)].

The shift-share decomposition of growth can be calculated as:

(2.5)

Regional Growth = National Growth Share (NS) + Sectoral-Mix Share (SM) + Region-Specific Share (RS)

where:

NS $= x_{t-1} \; (X_t/X_{t-1} - 1)$,

SM $= x_{t-1} \; (X_{it}/X_{it-1} - X_t/X_{t-1})$,

RS $= x_{t-1} \; (x_t/x_{t-1} - X_{it}/X_{it-1})$,

$x_t$ and $x_{t-1}$ = share of regional economic activity in sector i at time periods t and t-1,

$X_{it}$ and $X_{t-1}$ = regional share of national economic activity in sector i at time periods t and t-1, and

$X_t$ and $X_{t-1}$ = total national economic activity at time periods t and t-1.

The national growth share (NS) represents the growth that would have occurred in the region if all sectors had grown at the national growth rate. The national growth share acknowledges that some of the changes that occur in the regional economy are a function of national economic conditions.

The sectoral-mix share (SM) measures the growth that would have occurred if the region's sectors had grown at the same rate as these sectors in the national economy. Hence, it is assumed that the sectoral-mix share measures the effect of a region's economic structure on growth. The national average growth rate of individual sectors, $X_{it}$, will differ from that of the national average growth rate, $X_t$. The mix of faster or slower growing sectors in a region's sectoral-mix determines the sectoral-mix share. A region which has a higher proportion of slower-growing sectors than the nation will have a negative sectoral-mix share.

In shift-share analysis, the national growth and sectoral-mix shares are the 'expected values' of economic activity, and the region-specific share (RS) is the 'deviation' between expected and observed values. The region-specific share measures the residual change not accounted for by the national and sectoral-mix components, and is interpreted as a measure of regional competitiveness [Andrikopoulos et al. (1987); Moscovitch (1990)]. The region-specific share draws attention to an important, but often ignored aspect of economic diversification:

> "An area may grow rapidly either because it has blended a mix of fast growth industries (those of new products ..., or those with income elastic demands ...), or because it is acquiring a larger share of the older, slowly growing ones (the movement of the textile industry ... [from New England to the Southeast] is such a case [Thompson (1965), p.55]."

That is, regions with a higher proportion of slower-growing sectors than the nation can offset their negative sectoral-mix share by out-performing the national average growth rates.

This observation emphasizes the importance of sector- and region-specific analysis of economic structure and performance. This has not been the case with previous studies on economic diversification. A sector- and region-specific approach is taken for the conceptual framework and operational model presented in Chapters 3 and 4.

### 2.6.2 Portfolio Theory

Economic diversification may seem, at first, to contradict the concept of comparative advantage, where maximum growth can be attained by specialization. However, in a dynamic and unstable economic environment, growth may not be the only performance goal. Policymakers are also concerned about stability, which can have important implications for allocative efficiency and comparative advantage. Economic instability can lead to inefficiencies due to the costs associated with maintaining excess capital and labor resources during downswings, or attracting additional resources during upswings [Thompson (1965), p. 135].

According to the sectoral-diversity hypothesis, the production and trade of a variety of products stabilizes economic performance. This hypothesis is related to the concept of portfolio theory. Regional scientists have used two types of measures of diversity to test the sectoral-diversity hypothesis: (i) measures of a concentration, and (ii) measures of stability.

#### 2.6.2.1 Measures of Concentration

It is a common perception that economic diversity is a function of both the number of sectors in a region, and the distribution of economic activity among them. A greater number of sectors, and a more even distribution of economic activity are often associated with economic diversity.

Measures of sectoral concentration, such as concentration ratios, the ogive index, and the entropy index have been used to measure sectoral diversity. These measures are based on the intuitive notion of diversity as the absence of concentration. The well-known admonition: 'Don't put all your eggs in one basket' reflects this notion. A region with a high concentration of economic activity ratio is considered a specialized region, whereas a region with a low concentration of economic activity is considered a diversified region. Clearly, such a classification is extremely sensitive to the selection of the measure of economic activity, and the level of aggregation.

Concentration ratios are widely used in industrial organization studies to assess the existence of firm dominance in a sector (i.e., to assess whether the 'balance of power' between firms in a sector is conducive to perfect competition). McLaughlin (1930) uses a measure of economic diversity that is based on concentration ratios of a region's dominant sectors.

Tress (1938) introduces the ogive index of economic diversity. The ogive index is similar to the Gini coefficient and its graphical counterpart the Lorenz curve, which are widely used by economists to measure the distribution of income among individuals. The ogive index of regional income by sector can be presented graphically (like a Lorenz curve) by plotting a cumulative frequency distribution of the percent of regional income against the number of sectors. Using the ogive index as a measure of economic diversity, the closer the plotted data to the 45° diagonal (which indicates an equiproportional distribution), the greater the diversity of economic activity.

The ogive index for a given region can be expressed as:

(2.6)

$$Ogive\ Index = \sum_{n=1}^{N} \frac{(X_n - 1/N)^2}{1/N} ,$$

where:

N = the total number of sectors into which the regional economy has been divided for purposes of the analysis,

1/N = the sectoral share of economic activity in the nth sector if all sectoral shares are equally distributed, and

$X_n$ = the actual sectoral share of economic activity for the nth sector.

The ogive index is an example of a goodness-of-fit measure of economic diversity. In Section 2.4 some of the shortcomings of this type of a measure were pointed out (e.g., sensitivity to the standard and the level of aggregation, and the lack of sectoral weights).

For the ogive index, the standard by which the goodness-of-fit is measured is 1/N. With N sectors, an equal distribution of sectoral activity implies that $X_n$ is equal to 1/N, the 'ideal' share for each sector, and the ogive index equals zero. This is referred to as 'perfect diversification'. A more unequal distribution of sectoral activity will result in a higher ogive index. If all of a region's economic activity is in a single sector, this is referred to as 'perfect specialization'.

An alternative measure of economic diversity is the entropy index, which can be expressed as:

(2.7)

$$\textit{Entropy Index} = -\sum_{n=1}^{N} X_n \ln X_n \ ,$$

where $X_n$ is the sectoral share of economic activity, and N is the number of sectors into which the regional economy has been divided.

If all of a region's employment or income is concentrated in a single sector, then $X_n=1$, and the value of the entropy index equals zero. This indicates 'perfect specialization'. If regional employment or income is equally distributed among the N sectors then the entropy index achieves its maximum value, ln N, which indicates 'perfect diversification'. The entropy index is similar to the 'Theil index', which, like the Gini coefficient, is widely used by economists to measure the distribution of income among individuals.

Both the ogive and entropy indices define 'perfect diversification', or the ideal economic structure, as an equiproportional balance of economic activity by sector. Therefore, the ogive and entropy indices give similar rankings among regions [Wasylenko and Erickson (1978)].

Referring to 'perfect diversification' as an equal balance of economic activity implies that the process of diversification has achieved its maximum, or equilibrium state. "In a naive way, this definition of diversification relies on the 'law of large numbers' in a global general equilibrium framework [Kerr (1989), p.39]."

The entropy index, which regional economists began to use in the 1970's [Garrison (1974); Hackbart and Anderson (1975)] is the most popular measure of sectoral concentration currently used by researchers. The principal empirical advantage of the entropy index over the ogive index is that it can be decomposed in order to analyze how subgroups of sectors contribute to overall regional economic diversity [Attaran (1986); Attaran and Zwick (1987a; 1987b; 1989); Garrison (1974); Hackbart and Anderson (1975); Smith and Weber (1984)]. According to a recent study, "The best single measure of diversity is the entropy measure [Malizia and Ke (1991), p.47]."

A perceived advantage of the entropy index is its 'scientific' basis, since it is based on the second law of thermodynamics--the entropy law. According to the entropy law, every time energy is transformed from one state to another there is a loss in the amount of available energy. The equilibrium state occurs when entropy reaches a maximum, where there is no longer free energy available to perform additional work. Most importantly, according to the entropy law, all systems tend towards maximum entropy [Rifkin (1980)]. The terms equilibrium state and maximum have a natural appeal to regional scientists seeking the ideal measure of economic diversity.

A recent study "An Information Theory Approach to Measuring Industrial Diversification" by Attaran and Zwick [(1989), p.19] begins: "Entropy as a measure of disorder, uncertainty, or homogeneity, has been used to analyze many different phenomena. In the physical sciences, it has been used to measure the irreversible increase of 'unavailable energy'. In the biological sciences and behavioral sciences, entropy has been used as a measure of organization. In communication theory, it quantifies the degree of uncertainty in a system." Hence, the title of the article. However, the relevance of the concept of entropy to regional economic structure is not transparent.

There is no *a priori* economic reason why a region's sectors should be expected to have equal shares of economic activity, given inherent sectoral differences in patterns of demand, production technology, and trade flows, and given inherent differences in the endowments and preferences of regions.

Kort (1981) uses the entropy index as a measure of economic diversity, but then emphasizes that it does not suggest that a region should have an equal distribution of economic activity among sectors. These indices "simply state that if a region's employment were equally distributed among all ... [sectors], then further diversification is, by any definition, impossible [Kort (1981), p.601]." These measures of diversity do not provide a guide for diversification policies that entail changes in economic structure in pursuit of performance goals. The entropy and ogive indices merely provide a reference point between the states of perfect diversity and perfect 'specialty'. Although a functional relationship between diversity and stability may be established based on equations (2.1) and (2.2), it still does not provide policy-relevant information on the relationship between changing economic structure and performance. That is, although there may be a positive relationship between diversity and stability, where the ogive index or entropy index are used as measures of RED, the relationship between the changes in sectoral shares (i.e., change in economic structure) and stability (i.e., performance) can not be modelled.

### 2.6.2.2 Measures of Stability

Conroy (1974; 1975) proposed the 'portfolio variance' as an analytically superior and policy-relevant approach to define and measure economic diversity and diversification. Every region is faced by a limited set of resources with which to produce a stream of stochastic 'returns' (e.g., income and employment) for its residents. If every sector is characterized as an individual regional investment, then the bundle of sectors may be considered a 'portfolio' of regional investments, among which the region's economic resources are allocated. In the context of portfolio theory, economic diversification refers to the explicit attempt to reduce instability in aggregate returns to the region from its portfolio of sectors. This approach to economic diversification focuses attention on the stability of returns from individual sectors, and also on the interdependence of fluctuations between sectors in the region's portfolio [Conroy (1975), p.495]. Note that Conroy (1974; 1975) refer to "returns" (i.e., economic performance), and then proceed to use the portfolio variance as a measure of economic structure.

Portfolio theory was conceived for applications to financial assets. Using the mean as a proxy for expected returns (E) and the variance (V) as a proxy for risk, the Markowitz portfolio method determines the set of mean-variance (E-V) efficient portfolios. According to the Markowitz portfolio method the expected value of returns for a given investor is:

(2.8)

$$E = \sum_{i=1}^{N} W_i \, X_i \ ,$$

the variance of returns is:

(2.9)

$$V = \sum_{i=1}^{N} \sum_{j=1}^{N} W_i W_j \ COV[X_i, X_j] \ ,$$

and the set of E-V efficient portfolios is calculated by maximizing M:

(2.10)

$$M = E - \lambda \ V \ ,$$

where:

$W_i$ = the share of the ith asset in the portfolio,

$W_i \geq 0$ for all i,

$\Sigma \ W_i = 1$,

$X_i$ = the expected rate of return for the ith asset,

$COV[X_i,X_j]$ = the covariance of returns between the ith and jth assets (the variance of returns for the ith asset is $VAR[X_i] = COV[X_i,X_i]$), and

$\lambda$ = is a constant that measures the investor's risk preference, where $\lambda < 0$ (=0, >0) for risk averse (neutral, seeking) investors.

The optimization problem expressed in equation (2.10) can be solved using non-linear mathematical programming procedures, such as quadratic programming.

Based on equation (2.9), a region's portfolio variance can be decomposed into variance and covariance terms as:

(2.11)

$$V = \sum_{i=1}^{N} W_i^2 \, VAR[X_i] + \sum_{i=1}^{N} \sum_{j=1, j \neq i}^{N} W_i \, W_j \, COV\,[X_i, X_j] \;,$$

where $W_i$ and $W_j$ are the shares of economic activity in the ith and jth sectors, $VAR[X_i]$ is the variance for ith sector, and $COV[X_i,X_j]$ is the covariance for the ith and jth sectors. Using equation (2.11), a region's economic stability can be decomposed into the stability due to: (i) individual sectors' fluctuations, and (ii) intersectoral fluctuations.

Conroy (1974; 1975), and others, have calculated the portfolio variance using normalized variances and covariances. The variances and covariances can be normalized using either the mean:

(2.12)

$$COV[X_i, X_j] = \frac{1}{T_*} \sum_{t=1}^{T_*} \frac{X_{it} - \hat{X}_{it}}{\bar{X}_i} \cdot \frac{X_{jt} - \hat{X}_{jt}}{\bar{X}_j} \;,$$

or using the trend. The appropriate choice depends on whether or not the relevant time series was characterized by a time invariant trend (i.e., mean) or time variant trend.

Covariance and correlation coefficients are closely related. The covariance matrix can be expressed as:

(2.13)

$$COV[X_i, X_j] = \rho_{ij}\sigma_i\sigma_j ,$$

where $\rho_{ij}$ is the correlation coefficient, and $\sigma_i$ and $\sigma_j$ are standard deviations.

Unlike measures of concentration, portfolio variance is a goodness-of-fit measure (where the standard is the expected level of economic activity) that incorporates the contribution of each sector's share (i.e., the $W_i$ and $W_j$ weights) into region-wide economic stability. As the sectoral shares change, the weights associated with individual variances and covariances change. These changing weights affect the total portfolio variance. Economic diversification, in the context of the portfolio variance approach, refers to reducing economic instability by varying the relative shares of different sectors.

The correlation of fluctuations between sectors plays a major role in determining region-wide economic stability. If economic returns (e.g., income or employment) from the ith and jth sectors are negatively correlated, $-1 \leq \rho_{ij} < 0$, the covariance lowers the overall variance of the region's portfolio. By choosing alternative sectoral mixes and examining correlation coefficients, the portfolio variance can be minimized. This allows for the comparison of impacts from different sectoral mixes on regional economic instability (clearly, it is also important to examine the variances, because a negative covariance may not offset a very high variance). Hence, in some studies, the portfolio variance has been considered a policy-relevant measure of economic diversity and diversification.

Some studies have tested the sectoral-diversity hypothesis using the regional portfolio variance, V, as a measure of economic diversity [Brewer and Moomaw (1985; 1986); Conroy (1974; 1975); Kurre and Weller (1989; 1990); Kurre and Woodruff (1991)]. In these cases a lower V means a more diversified regional economy. Using equation (2.2) in Section 2.3, some of these studies have also compared the portfolio variance to other measures of economic diversity [Brewer and Moomaw (1985; 1986); Conroy (1974; 1975)]. They claim that the portfolio variance is a superior measure of economic diversity (compared to the ogive index, entropy index, national averages index, and percent durable goods) because it is a better explanatory variable (i.e., the t-statistics and $R^2$ are higher for equations using V as a measure of RED).

However, portfolio variance should not be used to test the sectoral-diversity hypothesis, because the portfolio variance does not measure diversity independent of instability. As pointed out by Sherwood-Call [(1990), p.20]:

> "the portfolio variance measure of diversity, correctly calculated, is exactly the same as a region's total variance, which is a frequently-used measure of economic instability [REI in equation (2.3)]. Therefore, the portfolio variance measure does not measure diversity independent of volatility, and it is not surprising that the portfolio variance measure tends to 'explain' differences in volatility better than other 'diversity' measures."

Thus, it is appropriate to use the portfolio variance as a measure of economic instability (i.e., economic performance), or as a measure of economic diversity (i.e., economic structure). However, it is not appropriate to use it as a measure of diversification. Gruben and Phillips (1989) use the portfolio variance as a measure of economic instability. Using equation (2.11) to decompose economic instability into the variance and covariance components, they analyze sectoral and intersectoral sources of instability.

In addition to portfolio variance, 'portfolio beta' has been used as a measure of economic stability [Brown and Pheasant (1985; 1986); Kraybill and Orden (1987)]. The portfolio beta is calculated using the Sharpe single-index portfolio method, which was proposed as a procedure to reduce the data requirements that are requisite for calculating the full variance-covariance matrix.

The applications of the portfolio beta by Brown and Pheasant (1985; 1986), and by Kraybill and Orden (1987) were all for rural regions, for which data constraints exist. Schoening and Sweeney (1989; 1991) used portfolio variance to analyze instability in rural regions. They made specific references to the data problems, and the conceptual problems associated with applying the portfolio variance approach to economic diversification in rural regions.

Most applications of portfolio theory in the analysis of economic diversification have focused attention on economic stability and not growth-stability tradeoffs. Although the portfolio variance in equation (2.9) provides a unique rank-ordering of all portfolios for a given level of expected returns, it does not allow for the determination of a region's optimal sectoral portfolio, since neither the expected returns for individual sectors, nor the policymaker's attitudes toward risk are considered as they are in equation (2.10).

Using portfolio variance as a guide in the evaluation of alternative development strategies (i.e., diversification policies) implicitly assumes that decisions are based on the objective function of a risk averse policymaker or planner whose sole goal is to minimize regional economic instability. Economic growth or decline, as well as distributional impacts, are ignored in this approach to economic diversification. Stable decline and stable growth would produce equivalent results. Alternatively it could be claimed that this approach is based on the assumption that the region's growth rates and distributional impacts are satisfactory, or that growth, stability, and favorable distributional impacts are positively correlated. While these assumptions may be valid for some regions, they are not valid for many rural regions.

Some studies have proposed a portfolio theoretic approach to regional economic diversification that can incorporate E-V tradeoffs [Barth et al. (1975); Board and Sutcliffe (1991); Bolton (1989); Brewer (1985); Cho and Schuerman (1980); Gilchrist and St. Louis (1991); St. Louis (1980); Smith and Weber (1984); Steib and Rittenoure (1989)]. Furthermore, some of these studies propose region-specific operational models that measure growth-stability tradeoffs [Board and Sutcliffe (1991); Bolton (1989); Cho and Schuerman (1980); Gilchrist and St. Louis (1991)]. The objective of these operational models is to provide a basis for calculating regional economic impacts of alternative sectoral mixes. However, as discussed below, and in Chapter 4, these operational models have some conceptual and operational shortcomings.

Portfolio theory is based on the workings of financial asset markets. Applying concepts from portfolio theory to the workings of regional economies may not be appropriate. In financial markets, investors who accept greater risk can usually expect to receive greater returns on their investments. Investors prefer the least possible risk at any given level of return, so prices for assets that face little risk are bid up, thus reducing their returns relative to the prices of assets that offer the same yield with more risk. Therefore, the financial market bidding process results in a trade-off between risk and return [Sherwood-Call (1990), p.19]. Under such a risk-return tradeoff mechanism, risk averse regions would accept greater economic instability only if they were compensated in the form of higher growth rates. However, unlike financial markets, in the case of regional economies no such tradeoff mechanism is assured.

Furthermore, according to Sherwood-Call [(1990), p.19] financial assets and regional assets also differ because:

(a) Financial assets earn the same return regardless of who holds the portfolio, whereas a firm or sector may perform differently depending on where they are located,

(b) Differences in economic structure may limit the extent to which regions can and should diversify their economies,

(c) The transaction costs and time lags for changing the mix of assets in a financial portfolio are minimal, whereas there may be high costs and significant time lags associated with changing the sectoral mix in a region's economic portfolio, and

(d) A region's decisionmakers cannot 'trade' in a 'market' for firms and sectors the way investors can trade in a market for financial assets. Although regions may attempt to attract targeted firms and sectors using tax incentives, infrastructure investments, zoning variances, and so forth, the 'market' is thin and adjustments are slow. That is, regions do not have the same degree of control over their portfolio as do investors.

The use of the portfolio theory as the conceptual framework for addressing the issues related to regional economic diversification is questionable. However, portfolio theory and the portfolio variance approach do provide some valuable insights into the analysis of regional economic diversification, such as: (i) the need to consider growth and stability simultaneously, (ii) the need to consider intersectoral relations, and (iii) the need to calculate measures of instability using sectoral shares. The conceptual framework and operational model presented in Chapters 3 and 4 incorporate these points. Unlike previous studies in the regional science literature (with the exception of Cho and Schuerman (1980)), in this study input-output analysis serves as the basis for addressing the subject of regional economic diversification.

### 2.6.3 Economic Base Theory

Economic base theory views regional economic growth as being driven by exogenous demands, notably exports from the region. Export sectors are considered the economic base (the basic sectors) of the regional economy. Sectors that produce goods and services for regional use are considered non-basic sectors. A region's base multiplier, the ratio of basic plus non-basic economic activity to basic economic activity, is used to calculate the amount of regional economic activity generated by each dollar of basic sector sales. The base multiplier is often used to estimate the economic growth impacts of expanding an existing sector or introducing a new sector into a region's economy. However, using a regional base multiplier assumes that all sectors have the same economic impact. Clearly, better estimates of economic impacts can be calculated if the regional base multiplier can be calculated on a sector-by-sector basis.

Input-output models are an extension of the economic base model, whereby intersectoral economic relationships are considered. Details on household income and consumption can also be endogenized in an extended input-output model. Input-output models can be used to analyze distributional impacts on sectors, occupations, households, and individuals. An input-output model, which is extended to include social accounts, serves as the basis of the conceptual framework and operational model presented in Chapters 3 and 4.

Based on the assumption that economic growth can be enhanced by promoting sectors with larger intersectoral linkages, researchers and planners have devoted considerable attention to the identification of 'key sectors'. Key sectors are sectors that have a greater than average impact on the regional economy [Hewings (1982), p.173]. Various measures of intersectoral linkages based on input-output multipliers have been used [Basu (1990); Deman (1991)].

Because of the underlying assumption in economic base (and input-output) studies that the regional economy is driven by exogenous demand, there is a need to distinguish between a region's basic and non-basic sectors. In most cases simplifying assumptions are used to make the distinction between basic and non-basic sectors. In the regional science literature, base sectors are often associated with economic specialization.

The simplest method to identify basic and non-basic sectors is to assume that all primary (natural resource-based) sectors and secondary (manufacturing) sectors are basic, and that all tertiary (service) sectors are non-basic. This method is based on the assumption that primary and secondary sectors are production-oriented activities primarily destined for export, whereas tertiary sectors are consumption-oriented activities destined for the region's residents. In the modern 'service economy' many services (e.g., information services) are, however, related to basic activities.

Localization coefficients are often calculated to identify a region's basic and non-basic sectors. A popular measure is the location quotient (LQ), whereby sectoral economic activity (usually measured by sectoral employment or income) in a region is compared to the national average (i.e., the LQ is a ratio of regional:national shares of economic activity). Sectors with LQ > 1 are assumed to be basic sectors. The proportion of regional economic activity greater than unity represents basic economic activity (i.e., specialization), which is destined for export markets. The so-called 'measure of specialization' is an aggregate sector-by-sector that measure a region's LQs [Harmston (1983), p.306].

> "For the regional analyst seeking to implement a policy of diversification, a series of localization coefficients... could be useful. It could provide the basis for preliminary and tentative judgment about the industries to seek and encourage or at least to investigate further. Industries with low coefficients are relatively nonconcentrated regionally and are thus presumably amenable to location in a region seeking industrial diversification [Isard (1976), p.252]."

The national-averages index is a 'measure of specialization' that is a widely used measure of economic diversity. The national-averages index can be calculated as:

(2.14)

$$National\text{-}Averages\ Index = \sum_{i=1}^{N} \frac{(X_i - Xall_i)^2}{Xall_i}$$

where $X_i$ is the regional share of economic activity in sector i, and $Xall_i$ is the national average share of economic activity in sector i, with the sums of $X_i$ and $Xall_i$ both equal to one [Bahl et al. (1971); Lynch (1979)].

The national-averages index is another example of a goodness-of-fit measure. Other regional aggregates can be used as the standard for comparison, Xall. For example, to measure the economic diversity of rural regions, Sears et al. (1989) use the average sectoral composition of all non-metropolitan counties as Xall in equation (2.14).

After repudiating the measures of economic diversity based on portfolio theory (measures of concentration and stability), Sherwood-Call [(1990, p.20] claims:

> "it is impossible to calculate an ideal 'diversified' industry mix that is different for each region and that distinguishes between ideal and actual industry structure... [However] the national industry mix provides a standard with which to gauge a region's industry structure."

Use of the national-averages index as a measure of sectoral diversity implies that regions seeking to diversify their economies should attempt to duplicate, as much as possible, the economic structure of the United States. However, as was the case with the measures of sectoral concentration, practitioners using the national-averages index as a measure of economic diversity offer disclaimers. For example, after choosing the national-averages index as a measure of economic diversity, Sherwood-Call [(1990, p.20] goes on to say:

"Of course, no region could (or should) duplicate the U.S. industrial structure precisely, since geographical differences in comparative advantage will determine the region's optimal industry structure to a significant extent. Nevertheless, for most regions, the U.S. industrial structure provides a standard for diversity that is more reasonable than the available alternatives."

In this study an alternative perspective is taken. No arbitrary standards are used to define and measure economic structure in terms of diversity, which has limited, if any, policy-relevance. Actually, as pointed out on numerous occasions, these arbitrary definitions and measures may actually be detrimental, because some may be mistakenly accepted as practical guidelines.

Another method for identifying basic sectors is the minimum-requirements technique. First, regions are grouped by population size (or other relevant criteria). Second, for each group, the shares of economic activity (e.g., employment or income) are ranked in order of magnitude for each sector. Third a minimum-requirements profile for each sector is prepared for each group of regions. The region in each group with the lowest sectoral share of economic activity is assumed to have the minimum-requirements needed to satisfy a region's domestic demands. A region's basic employment is thereby assumed to be any economic activity that exceeds the minimum-requirements of its group [Ben-David (1974), p.110]. The minimum-requirements index, which is a region-wide aggregation of deviations from sectoral minimum-requirements, has been used as a measure of economic diversity [Ullman and Dacey (1960)].

The minimum-requirements index can be calculated as:

(2.15)

$$\text{Minimum Requirements Index} = \sum_{i=1}^{N} \frac{(X_i - Xmin_i)^2}{Xmin_i}$$

where $X_i$ is the regional share of economic activity in sector i, $Xmin_i$ is the minimum required share of economic activity in sector i, and the sum of $X_i$ equal to one. This is another example of a goodness-of-fit measure.

Using the minimum-requirements index as a measure of economic structure is questionable. Pratt [(1968), p.119] criticized the minimum-requirements index as defining:

> "a rather strange economy in which every city exports and no city imports... The theory clearly precludes the importing of any goods or services either for direct internal consumption or for incorporation into goods being produced for local consumption."

Finally, it is common practice to identify a region's economic base on the basis of threshold sectoral shares of economic activity. For example, the USDA categorizes rural regions as farm-dependent, manufacturing-dependent, mining-dependent, and retiree-destination if the economic activity generated by one of these categories (measured as a share of sectoral income or employment) are above a given threshold. Using the USDA thresholds, Sears et al. (1989) categorize rural regions according to their economic base. Regions not grouped in a particular category are referred to as 'diversified'. This method of categorizing regions is clearly sensitive to the thresholds chosen.

The various measures of economic diversity described in this section have been used to test the regional-national sectoral composition hypothesis, and the sectoral-mix hypothesis. The theoretical justification for testing these hypothesis is regional business cycle theory, which is a stability-oriented counterpart of economic base theory.

### 2.6.4 Regional Business Cycle Theory

Regional business cycle theory specifically addresses the relationship between a region's economic structure and stability.

> "Most approaches to regional economic analysis--input-output tables, impact multiplier models, and shift-share analysis, for example--emphasize growth in employment or income but do not consider fluctuations in growth rates. An exception is the literature which attempts to tie a region's diversification in employment among economic sectors to its resistance to external business cycles [Brown and Pheasant (1985), p.51]."

Vining wrote several articles in the 1940's about national business cycles and regional differences in economic instability. Vining's approach to the study of regional economic instability resulting from national business cycles draws heavily on economic base theory [Domazlicky (1980), p.15]. Accordingly, it is assumed that a region's economic instability is primarily transmitted via changing patterns in the demand for its exports. This assumption is used to 'drive' the operational model presented in Chapter 4.

According to Vining (1946), high levels of economic instability are associated with a high short-run income elasticity of demand for a region's exports. Vining's work stimulated research into the relationship between a region's mix of exports and economic instability. His work provides the theoretical foundation for the sectoral-mix hypothesis.

Durable goods and production goods tend to have high short-run income elasticity of demand. Hence it is generally assumed that a region will be more cyclically sensitive the higher the share of durable goods in its export mix, or the higher the share of regional income or employment in durable goods sectors [Cutler and Hanz (1971); Siegel (1966)]. Because of this, the percent of durable goods in a region's exports mix, or the percent of the region's income or employment in durable goods sectors, has been a widely used measure of economic diversity [Domazlicky (1980)]. For rural regions, the percent share of sectors characterized by a high degree of instability, such as mining or recreation and tourism, have been used to test the sectoral-mix hypothesis [Sears et al. (1989); Smith and Gibson (1988)].

The minimum requirements index has also been used as a measure of economic diversity to test the sectoral-mix hypothesis [Ullman and Dacey (1960)]. Using the minimum-requirements index as a measure of economic diversity is based on the assumption that a highly trade-dependent region (either exports or imports) is more prone to economic instability.

The sectoral-mix hypothesis implies that regions should avoid sectors with unstable export demand. Alternatively, this could be interpreted as meaning that regions should try to specialize in sectors with stable export demand. For example, regions specializing in education and public administration are typically among the most stable regional economies [Wasylenko and Erickson (1978)]. Another policy implication may be to limit regional trade dependency in terms of both exports and imports. This is based on the desire to buffer the regional economy from exogenous fluctuations in both export-related and import-related demands.

The regional-national sectoral composition hypothesis is also based on regional business cycle theory. As mentioned earlier, this hypothesis implies that if a region's sectoral composition is similar to that of the nation, one may expect that the region will respond to business cycles in a manner similar to the nation as a whole. The national-averages index has been used to test the regional-national sectoral composition hypothesis. The implied policy implication of the regional-national sectoral composition hypothesis is for a region to try to emulate the national economic structure. This disregards region-specific characteristics, which are the focus of location theory.

### 2.6.5 Location Theory

Location theory, which is the foundation of regional economics, is used to examine the spatial distributions of economic activity. The most distinctive feature of the spatial economy is its heterogeneity. One of the salient characteristics of economic activities is their tendency to occur in spatial clusters. Agglomeration economies occur when firms and sectors benefit from the clustering of economic activities. Firms within a sector and economically linked sectors locate at one point because of the economies of size related to the spatial pricing of inputs (however, these economies of size are external to each firm or sector). The lower costs of production resulting from agglomeration economies are an important source of specialization and regional comparative advantage [Hoover and Giarratani (1984)].

In most cases agglomeration economies are associated with benefits emanating from linkages between a region's firms and sectors. However, a diverse regional economy with unlinked firms and sectors may also benefit from agglomeration economies. Firms and sectors having offsetting patterns of cyclical fluctuations may operate more efficiently if they are located together, thus providing some stability to an otherwise unstable situation. Where labor can shift easily among firms and sectors, it is hypothesized that a more stable level of employment can be achieved [Harmston (1983), p.86]. This possibility of intersectoral labor movement was raised by Tress (1938) (as mentioned in Section 2.5), and it is an underlying assumption of portfolio theoretic approaches to economic diversification. This subject is addressed in the context of the operational model in Chapter 4.

The sectoral-diversity, sectoral-mix, and regional-national sectoral composition hypotheses are all based on the implicit assumption that sectors are spatially homogeneous. However, sectors in different regions will respond differently to national business cycles. For example,

> "Since the industrial-mix hypothesis places full blame of regional economic instability on a disproportionate share of sensitive industries, it ignores all other characteristics of regions... Such exclusions imply that there is nothing particularly characteristic of a region which induces differences in economic stability... In fact, there are substantial regional differences in the structure, age and size of plants which preclude such spatial homogeneity of industries [Kort (1979), p.9-10]."

The region-size hypothesis, which has been tested using a region's population size as a measure of economic diversity, is based on the explicit assumption of spatial heterogeneity [Clemente and Sturgis (1971); Crowley (1973); Marshall (1975); Thompson (1965)]. Although a region's population size may be a good proxy for economic diversity (i.e., a greater variety of economic activity) this tautology does not provide a policy-relevant guide for designing alternative development strategies for rural regions, except that 'bigger is better'.

The growth-differentials hypothesis is a growth-oriented counterpart of the stability-oriented region-size hypothesis. The growth-differentials hypothesis assumes that declining regions are characterized by inefficient firms and sectors with excess capacity in plant, equipment and labor force that adjust utilization rates to cyclical changes in exogenous demand. In contrast, it is assumed that growing regions are characterized by efficient firms and sectors that are less responsive to cyclical changes in exogenous demand. As such,

> "there is a negative relation between overall cyclical variability and the long-term growth trend in a region: regions with the least growth would tend to be the most vulnerable to cyclical swings... Greater cyclical amplitudes will be associated with pools of unemployed labor, with high cost production facilities, and with declining segments of an industry [Borts (1960), p.181]."

Instead of a growth-stability tradeoff, as is assumed in portfolio theory, economic growth and stability may actually be complementary. This has important theoretical, empirical, and policy implications. If regional economic stability and growth are, in fact, positively correlated, then it is possible to focus attention on growth as a measure of performance. From theoretical, empirical, and policy perspectives, regional scientists and planners are better equipped to deal with the analysis and promotion of economic growth than economic stability. This will be observed in Chapters 3 and 4.

There are several spatial-development theories that deal with the concept of hierarchal relationships between regions, which are based on interregional flows of economic activity. These theories include central place theory, growth pole theory, product life-cycle theory, and dependency theory. The common thread of these theories is that some regions are the economic growth centers (i.e., the core) and some regions are the economic hinterland (i.e., the periphery).

According to spatial-hierarchal development theories, the movement from lower to higher orders in the spatial hierarchy is defined as the movement from lesser to greater regional economic diversity, a 'process' of diversification. The hierarchal system of regions is ordered according to the quantity and quality of economic functions performed by each region. Core regions are considered diversified because they produce a wide range of goods and services using modern technologies, with numerous intersectoral production and consumption linkages. Peripheral regions are considered specialized because they tend to concentrate on a narrow range of export-oriented natural resource-based raw materials or low-technology goods and services, with limited intersectoral production and consumption linkages. According to this definition, many rural regions are specialized and in the economic periphery.

The policy implication for rural regions that follows from this logic is that they should become more like urban regions. However, there are two important questions to be addressed: (i) "Do rural residents want their regions to become more like urban regions?", and (ii) "If they do, can they really make such a transformation?"

The contrasting economic roles of core and periphery regions are also functions of differences in the price and income elasticities of demand for their respective products and the respective stage of product development. Product life-cycle theories describe how new products tend to be developed in the core regions, which are centers of experimentation and innovation, and which also have the necessary productive technologies and resources, and local markets. As markets in the core are saturated, exports to the periphery expanded, and productive processes become standardized, the location of production shifts to the periphery [Norton (1986), p.10].

As can be observed from the spatial-hierarchal development theories, a region's stage of development is closely related to its economic structure and performance. That is, a region's demand, production technologies, and trade flows are all related to its stage of development. These relationships are addressed in economic development theory.

### 2.6.6 Economic Development Theory

The structural transformation process is one of the foundations of development economics [Syrquin (1988), p.205]. According to economic development theory, the concept of diversification is associated with the process of structural transformation. This is a dynamic concept of economic diversification.

The process of economic diversification is driven by concomitant changes in: (i) production patterns, (ii) consumption patterns, and (iii) trade patterns [Kuznets (1968), p.95]. The shift of economic activity from primary to secondary and tertiary sectors precipitated by changing patterns of production, consumption, and trade have major impacts on intersectoral relationships in a regional economy. As productive processes become more 'roundabout' there is a complex web of intermediate products that are required to produce the goods and services that comprise final demand [Skousen (1990), p.22].

The process of economic diversification is expedited by 'unbalanced growth', which is the faster growth of sectors with high income elasticities of demand for their products, and a simultaneous but slower growth of those sectors with low income elasticity of demand for their products. A development strategy for achieving unbalanced growth is to promote structural change in accordance with changing income elasticities of demand, subject to resource and technology constraints. Hence, the concept of a balanced economic structure is not based on the absence of concentration to achieve economic stability; it is based on adjusting economic structure to achieve specific performance goals [Harris (1989); Scitovsky (1989)]. In this context, unbalanced growth can lead to either a more or less balanced economic structure in terms of the sectoral shares of income and employment.

The process of economic diversification entails changes in absolute and relative levels of sectoral output, employment and income, due to changes in the structure of production, consumption and trade. Structural change is characterized by a redistribution of economic activity. The changing distribution of economic activity affects individuals, households, sectors, and regions. The distributional impacts of economic diversification are important aspects of the stages of growth development theory. Kuznets' 'inverted U hypothesis', which relates the stage of development to the distribution of income among individuals, was the first of numerous studies on the distributional impacts of structural change [Haslag et al. (1988)].

Development economists have attempted to define and measure economic diversification as a process of structural change.

> "[One of the] clearer meanings of the terms structure in economics... refer[s] to different arrangements of productive activity in the economy, especially to different distributions of productive factors among various sectors of the economy, various occupations, geographic regions, types of product, etc. Thus economists have spoken of structure of production to mean a cross-sectional distribution of inputs or outputs. Indeed, what we now call an input-output matrix of an economy is often referred to as a structure [Machlup (1958), p.282]."

In the absence of a formal model, it is convenient to define structural change as any shifts in the composition of selected economic aggregates. When discussing the causes or sources of structural change, however, it must be based on some model of the economy that specifies underlying stable relationships, even if only in imprecise terms. By using a model based on input-output analysis, it is possible to be more precise in the measurement of structural change, although the scope of the model limits the aspects of structural change that can be covered [Chenery (1978), p.108; Kubo et al. (1988), p.188].

The overwhelming advantage of using an input-output model to analyze structural change is the fact that economic performance is explicitly modelled as a function of economic structure. That is, in contrast to studies of economic diversity, an input-output model provides a conceptual and analytical framework to analyze the relationship between changing economic structure and economic performance, which is ostensibly the question addressed by many of the previous studies on regional economic diversification.

Input-output models, and extended input-output models have been widely used in studies of structural change. Two approaches have been used: (i) multiplier analysis, and (ii) decomposition of growth analysis.

Multiplier analysis focuses attention on temporal changes in the structure of production, which is depicted by a region's input-output coefficients. The economic diversification process is viewed in terms of changes in the input-output matrix. Most of the cells would be empty to start with, but would progressively fill up because of the widening and deepening of intersectoral production linkages [Hirschman (1989), p.211]. Recent examples of multiplier analysis, which also provide reviews of the literature, are in Basu (1990), Deman (1991), and Jensen, Dewhurst, et al. (1991).

Decomposition of growth analysis focuses attention on temporal changes in the structure of production, demand, and trade, which is depicted by a region's input-output accounts, social accounts, and accounts of trade flows. As mentioned in Section 2.6.3, an extended input-output model based on social accounts can be used to measure distributional impacts on individuals, households, occupations, and sectors (input-output accounts can be used to measure distributional impacts by sector). Hence, a decomposition of growth analysis is based on a more comprehensive measure of regional economic structure than multiplier analysis. The decomposition of growth analysis measures the multiplier (supply) and the multiplicand (demand), whereas the decomposition of multiplier analysis only measures supply. A decomposition of growth analysis is used in Chapter 3 to analyze the relationship between changing economic structure and performance. In addition, a decomposition of stability analysis is presented. The conceptual framework presented in Chapter 3 is the foundation of the operational model presented in Chapter 4.

## 2.7 CONCLUSION TO THIS CHAPTER

There is no single definition of economic diversification or diversity, but several definitions that sometimes overlap and sometimes conflict. The existence of multiple definitions explains, in part, the confusion about the meaning of economic diversification, its measures, and hypothesized relationships to economic performance. This confusion presents a serious dilemma for policymakers, planners, and citizens who contemplate or attempt implementation of an economic diversification policy.

In a review of studies on economic diversification that have appeared in the regional science literature during the past sixty years Kort [(1991), p.17] points out that (emphasis added):

> "With the recession of 1990-1 being experienced in all regions of the country, some which were barely touched by the recession of the 1980's, State and local policymakers are listening [to regional scientists]. States experiencing employment layoffs due to defense-related industry cutbacks certainly are listening. At least firms are; **they clearly see a need to diversify both labor and capital to produce nondefense goods in factories that were, until now, used for producing planes, tanks, missiles and other defense goods.**"

This passage is yet another example of the confusion that exists in the regional science literature, and is also indicative of some of the misconceptions about economic diversification found in studies on rural economic development. It is common to "clearly see a need to diversify" from a current economic activity to an alternative economic activity when performance is unsatisfactory. In almost all cases it is possible to replace the term 'diversify' with the term 'change'. In other words, 'if it doesn't work, fix it'. However, the regional science literature has not provided a policy-relevant instruction manual or tool-kit to address the subject of economic diversification.

There is need for a clearer understanding of the notion of economic diversification, one that can sort out the overlaps, contradictions and gaps in trade theory, portfolio theory, economic base theory, regional business cycle theory, location theory, and economic development theory. There is especially a need for a comprehensive conceptual framework and operational model that can synthesize the relevant aspects of these theories. The policy-relevant question that should be addressed is: "What is the relaticnship between a region's changing economic structure and performance?" This question will be addressed in Chapters 3 and 4.

# CHAPTER 3 CONCEPTUAL FRAMEWORK

"Perestroika is not a new reality for North American agriculture. Structural adjustments in agriculture, in rural communities and regions, and in economic activities associated with the production and trading of agricultural commodities are made frequently in response to recurrent changes in economic and political conditions. Increased interdependence of agriculture with other sectors within the national economy and worldwide amplifies the need for understanding the consequences of structural change, including the organization and control of the sector [Johnston (1990), p.1109]." Opening statement, Presidential Address to the American Association of Agricultural Economics, 1990.

## 3.0 INTRODUCTION TO THIS CHAPTER

As pointed out in Chapter 2, the policy-relevant question to be addressed is: "What is the relationship between a region's changing economic structure and its performance?" This chapter presents a conceptual framework for analyzing the relationship between a region's changing economic structure and performance. A region's economic structure and its relationship to economic performance are modelled using an extended input-output model, which is based on a system of material balance equations of social accounts. This model of a regional economy can be used to measure economic performance in terms of the growth, stability, and distribution of output, income, and employment. The model can also be used to measure other economic, social, environmental, etc. components of regional performance.

## 3.1 MEASURING REGIONAL ECONOMIC STRUCTURE AND PERFORMANCE

Social accounts, which include input-output accounts, can be used to construct a social accounting matrix (SAM). A region's SAM records the circular flow of economic activity. The SAM can be used to construct a series of identities (i.e., material balance equations) which describe a region's economic structure and performance at a given point in time. The material balance equations can be used to analyze what a region makes and consumes (sectoral mix), how it makes and trades it (intersectoral linkages), who does it (occupational mix), and how wage, capital, and transfer income are distributed.

The material balance equation of output by sector expresses the total output of each type of good and service as a function of the demand by other sectors in the region, the demand by households within the region, and the demand for regional goods and services generated by exports, government, and investment. To measure regional output, imports are deducted from the total circular flow.

Assuming fixed proportion production functions (i.e., the linearity of production), and that the consumption of households is a linear function of their income (i.e., marginal and average propensity to consume is equal), the material balance equation of sectoral output for a region with an open economy can be expressed as:

(3.1)

$$X = AX + CY_H + F_D - M ,$$

where:

X = nx1 vector of output by each of the region's n sectors,

A = nxn matrix of input-output coefficients,

AX = nx1 vector of sectoral intermediate demands,

C = nxk matrix of household consumption coefficients that allocate k household groups' expenditures among n sectors,

$Y_H$ = kx1 vector of income allocated by household group,

$CY_H$ = nx1 vector of sectoral household consumption demands,

$F_D$ = nx1 vector of sectoral final demand (which includes interregional and international exports, government demand for regionally produced goods and services, and investment from the n sectors), and

M = nx1 vector of sectoral imports.

Aggregation by sector assumes that firms within a sector use identical (or at least, extremely similar) production technologies to produce goods and services (i.e., sectoral output), and aggregation by households assumes that individual households within a household group have identical consumption patterns. The validity of these assumptions will depend on how accurately the level of aggregation reflects similarities and differences among firms and households.

The regional material balance equation for sectoral imports is:

(3.2)

$$M = m^{A}AX + m^{C}CY_{H} ,$$

where:

$m^{A}$ = nxn diagonal matrix of import coefficients for intermediate demands, and

$m^{C}$ = nxn diagonal matrix of import coefficients for final demand by households.

Combining equations (3.1) and (3.2) the regional balance equation for sectoral output can be written as:

(3.3)

$$X = (1-m^{A})AX + (1-m^{C})CY_{H} + F_{D} ,$$

or as:

(3.4)

$$X = p^{A}AX + p^{C}CY_{H} + F_{D} ,$$

where:

$p^A$ = nxn diagonal matrix of regional purchase coefficients for intermediate demands ($p_i^A = 1 - m_i^A$), and

$p^C$ = nxn diagonal matrix of regional purchase coefficients for household consumption demands ($p_i^C = 1 - m_i^C$).

Imports can be classified as competitive (i.e., perfect substitutes) or as non-competitive (i.e., non-substitutes). Competitive imports may or may not be currently produced in the region, but the potential for competitive domestic production exists ($0 \leq p_i^A \leq 1$ and $0 \leq p_i^C \leq 1$). Imports and regionally produced goods within the same sector classification are considered perfect substitutes. It may be physically impossible for a region to produce certain natural resource based commodities, and imports from such sectors are considered non-competitive imports. There may also be insurmountable technological constraints in the foreseeable future. Non-competitive imports are not included in a region's A matrix.

The regional purchase coefficient, $p_i^A$ or $p_i^C$, for a given sector is defined as the proportion of regional demand for its output that is produced within the region. In equation (3.4), the regional purchase coefficients are diagonal matrices because it is assumed that $p_i^A$ and $p_i^C$ are the same for all j sectors or k households that purchase the ith sector's good or service. This assumption is similar to the linearity assumptions used for production and consumption relationships in equation (3.1). Assuming the linearity of production, consumption, and trade relations; the material balance equations can be used to construct an input-output model of a regional economy.

An input-output model based on the solution of the system of linear material balance equations is a general equilibrium measure of a region's economic structure and performance. An input-output model can be used to calculate direct, indirect, and induced economic impacts. Direct economic impacts are the payments received by producers for final purchases of goods and services by the region's consumers and by governments (local, state, and federal), payments received by producers for investment goods for other regional producers, and payments for exports (including goods and services purchased in the region by non-residents). Indirect economic impacts are the expenditures by producers on the factors of production, the 'backward linkages' to input supply sectors affected by the direct regional economic impacts. Induced economic impacts are the subsequent consumption-related regional expenditures on goods and services resulting from the income received by households involved in the direct and indirect economic impacts. By convention, input-output models that calculate direct plus indirect impacts are called 'Type I', or open models. Input-output models that calculate direct plus indirect plus induced impacts are called 'Type II', or closed models.

Type II impacts can be calculated by 'closing' the input-output model with respect to households. This is done by endogenizing sectoral household consumption demands by households in the region. Since sectoral household consumption demands are a function of household income, a regional material balance equation for household income is required to close the model. The closed input-output model uses household consumption data from social accounts. Hence, a closed input-output model is a SAM-based model that is an extension of the open input-output model.

The region's material balance equation for household income is:

(3.5)

$$Y_H = VX + F_C ,$$

where:

$Y_H$ = kx1 vector of household income allocated to k household groups,

V = kxn matrix of value-added coefficients; wage and capital income received by k household groups for 'sales' of their factors of production to the n sectors,

VX = kx1 vector of the allocation of value-added (i.e., income) to the k household groups from sources endogenous to the input-output model, and

$F_C$ = kx1 vector of the allocation of income to the k household groups from sources exogenous to the input-output model.

In equation (3.5) regional income is divided into endogenous and exogenous components. The endogenous component, VX, includes the wages, salaries, and proprietors' income resulting from regional economic activity. The exogenous component, $F_C$, includes transfer payments (e.g., social security, unemployment benefits, and other public assistance), income received by residents who are out-commuters, rental payments on assets held outside the region, and dividend payments from extra-regional firms.

In equation (3.5) it is assumed that the various components of $F_C$ are exogenous to regional economic activity. In practice, some types of transfer payments, notably unemployment benefits, are linked to the level of economic activity. The input-output model can be extended to endogenize transfer payments that are linked to the level of economic activity [Bernat (forthcoming)].

The matrix of value-added coefficients, V, can be decomposed as such:

(3.6)

$$V = QWS \ ,$$

where:

S = sxn occupation-output coefficient matrix; the number of employees in each of s occupational groups required per dollar of output in each of the n sectors,

W = sxs income-occupation coefficient diagonal matrix; the wage and capital income (i.e., value-added) received by each of the s occupation classes (i.e., average earnings by occupation group), and

Q = kxs occupation-household conversion matrix; the probability that a worker of a particular occupation group will be in a particular household group ordered by income.

To calculate the closed input-output model for sectoral output, equations (3.4), (3.5), and (3.6) are combined to give the following system of regional material balance equations:

(3.7)

$$X = p^{A}AX + p^{C}CQWSX + p^{C}CF_{C} + F_{D} \ ,$$

where:

$p^{A}AX$ = nx1 vector of intermediate demands,

$p^{C}CQWSX$ = nx1 vector of household consumption demands from income generated by regional production, and

$p^{C}CF_{C}$ = nx1 vector of household consumption demands from income not generated by regional production.

This system of equations can be solved as:

(3.8)

$$X = (I - p^{A}A - p^{C}CQWS)^{-1}(p^{C}CF_{C} + F_{D}) \ ,$$

where:

$(I - p^A A - p^C CQWS)^{-1}$ = nxn matrix of the region's sectoral output multiplier coefficients, and

$(p^C CF_C + F_D)$ = nx1 vector of the region's sectoral final demands.

In equation (3.8) the direct impacts are the vector of sectoral final demands $(p^C CF_C + F_D)$. Indirect impacts are associated with the contribution of $p^A A$, and induced impacts are associated with the contribution of $p^C CQWS$ to $(I - p^A A - p^C CQWS)^{-1}$. It is important to point out that, by construction, $\Sigma_i a_{ij} + \Sigma_k v_{kj} = 1$. That is, the ith sector's purchases can be divided into payments to backward-linked sectors, $\Sigma_i a_{ij}$, and payments to households, $\Sigma_k v_{kj}$. Backward-linked sectors receive payments for the supply of intermediate inputs, and households receive payments for the supply of factors of production (e.g., labor and capital) to the ith sector's output.

This chapter presents a conceptual framework and does not deal with data issues or the actual construction of an extended input-output model. Basu (1990), Bernat (1985), Bernat (forthcoming), Painton (1991), and Rose et al. (1988) present detailed information on data sources and model construction.

The material balance equations and extended input-output model presented in equations (3.1) to (3.8) are applicable at the regional or national level. In fact, many regional input-output models are based, at least in part, on national-level data. In most regional input-output models region-specific characteristics of economic structure and performance are depicted through the regional purchase coefficients, $p^A$ and $p^C$, and the exogenous final demands, $F_D$ and $F_C$. That is, trade flows are region-specific, whereas production and consumption relationships are based on national averages. From an applied perspective, using a combination of region-specific and national-level data has some advantages. However, from a conceptual perspective, which is the perspective used in this chapter, it will be assumed that the A matrix, and the C, Q, W, and S coefficients are region-specific (in addition to $p^A$, $p^C$, $F_D$, and $F_C$).

Each region's A matrix can be conceptualized as an input-output table that depicts actual and potential intersectoral relationships. A region's actual intersectoral relationships can be depicted by $p^A A$, where $0 < p_i^A \leq 1$ and potential intersectoral relationships by $p^A A$, where $p_i^A = 0$. As such, the expansion or contraction of existing intersectoral activities are depicted by changes in $p_i^A$, where $p_i^A > 0$, and new intersectoral activities by changes from $p_i^A = 0$ to $p_i^A > 0$. Hence the 'widening' or 'deepening' of intersectoral linkages can be accomplished either by changes in trade flows for a given technology (changes in $p^A$), or by changes in technology for given trade flows (changes in A). Similarly, a region's actual intersectoral activity based on consumption demands is depicted by $p^C CQWS$, where $0 < p_i^C \leq 1$ and potential intersectoral relationships by $p^C CQWS$ where $p_i^C = 0$. Changes in $p^A$, A, and $p^C$, and their respective impacts on economic structure and performance, are addressed later in this chapter.

If $p_i^A$ or $p_i^C$ equal zero, then the ith sector does not currently exist in the region. However, since it is assumed that the A matrix has input-output coefficients for all existing and potential sectors, it is possible to model the impacts of adding new economic activities into the region. This is useful from both conceptual and applied perspectives, since it is possible to simulate alternative development strategies.

The coefficients A, $p^A$, $p^C$, C, Q, W, and S in equation (3.8) can be referred to as 'structural factors'. The levels of $F_C$ and $F_D$ can be referred to as 'exogenous final demands'. In standard input-output analysis, it is assumed that the structural factors are fixed, whereas the exogenous final demands are assumed to be variable. Also, the standard input-output model is a fixed-price model. Since a standard (i.e., static) input-output model assumes fixed structural factors and fixed prices, it assumes a linear response to changes in exogenous final demands (i.e., no resource constraints, frictionless adjustments, and no substitution among inputs). That is, the standard input-output model assumes constant returns to scale.

Extensions of the standard input-output model, such as dynamic input-output models and computable general equilibrium models are explicit attempts to model nonlinear changes in structural factors (i.e., resource constraints, adjustments with friction, and substitution among inputs), and changing relative prices [Johnson (1986); Kraybill (1989)].

In compact notation, sectoral output can be written as:

(3.9)

$$X = RF ,$$

where the sectoral output (or SAM) multiplier is:

(3.10)

$$R = (I - p^A A - p^C CQWS)^{-1} ,$$

and exogenous final demands by sector are:

(3.11)

$$F = p^C CF_C + F_D .$$

According to economic base theory, a region's exogenous final demands, F, are the 'engine' that drives the regional economy. The sectoral output multiplier matrix, R, reflects a region's comparative advantage. According to trade theory, location theory, and economic development theory, each region's sectoral output multiplier is based on region-specific sectoral production functions, household consumption demand, and regional purchase coefficients. Hence, two regions facing identical vectors of exogenous final demands, F, might have different levels of sectoral output, X, due to differences in intersectoral linkages.

Some measures of a region's economic, social, environmental, etc. performance can be calculated by multiplying the vector of sectoral output, X, by a 'response coefficient'. A response coefficient quantifies the correspondence between one measure of regional economic performance--the level of output by sector, X--to some other measure of regional performance [Palmer et al. (1985), p.3-36]. In most applications of input-output models, the various response coefficients map a linear correspondence with X. That is, it is assumed that these measures of regional performance are linear functions of X.

However, in some cases, it may be possible to use response coefficients that quantify a nonlinear correspondence with X. This adds additional flexibility to the standard input-output model of a regional economy. Hence, the standard input-output model can be extended to incorporate some nonlinear relationships, without resorting to a 'full-fledged' dynamic input-output model or computable general equilibrium model.

By definition, a response coefficient designates the aggregation scheme used to measure regional performance. In turn, the aggregation scheme determines the basis for analyzing distributional impacts. Issues related to a region's social welfare, aggregation schemes, and distributional impacts are addressed in Chapter 4.

Measures of regional economic performance can be aggregated by sector or according to some other aggregation scheme. The two most widely used measures of economic performance are income and employment, aggregated by sector. When these measures are used, the basis for analyzing distributional impacts is income or employment by sector. Equation (3.9) can be extended to calculate the level of a region's income and employment by sector.

Regional income by sector can calculated as:

(3.12)

$$Y_* = W_* S_* X = W_* S_* RF ,$$

where:

$Y_*$ = nx1 vector of regional income levels by sector,

$S_*$ = nxn matrix of sectoral employment-output coefficients; the number of employees in each of n sectors required per dollar of output in each of the sectors, and

$W_*$ = nxn diagonal matrix of income-occupation coefficients; the income (value-added) received by each of the n sectors' employees (i.e., average earnings by sector).

Regional employment by sector can be calculated as:

(3.13)

$$L_* = S_* X = S_* RF ,$$

where:

$L_*$ = nx1 vector of regional employment levels by sector.

For the conceptual framework presented in this chapter and for the operational model presented in Chapter 4, measures of a region's economic structure and performance are based on income and employment aggregated by occupation group. The analysis of distributional impacts, which is described in Chapter 4, is based on this aggregation scheme. Equation (3.9) can be used to calculate the level of a region's income and employment by occupation group.

Regional income by occupation group is calculated as:

(3.14)

$$Y = WSX = WSRF \ ,$$

where:

Y = sx1 vector of regional income levels by occupation group, and

WS = sxn matrix that relates value-added by occupation to output by sector, the value-added received by each of the s occupational groups per dollar of output in the n sectors (S and W were defined in equation (3.6)).

Regional employment by occupation group is calculated as:

(3.15)

$$L = SX = SRF \ ,$$

where:

L = sx1 vector of regional employment levels by occupation group.

Other measures of regional performance can be calculated using response coefficients. For example, sectoral pollution coefficients can be used to calculate environmental impacts. To calculate the pollution associated with a given level of sectoral output (i.e., the pollution generated by intersectoral economic activity) a matrix of pollution response coefficients, $V_{kj}$, is needed, whereby a given amount of pollutant type k, measured in physical units is generated per dollar's worth of sector j's output [Miller and Blair (1985), p.237]. That is, it is assumed that there is a linear functional relationship between sectoral output and pollution. Hence, the level of pollution associated with a given level of sectoral output can be expressed as:

(3.16)

$$V_* = VX = VRF ,$$

where:

$V_*$ = kx1 vector of pollution by type of pollutant.

Equations (3.12) to (3.16) all point to the centrality of the relationship X = RF in the analysis of regional economic structure and performance. In the following sections an analysis of the structural sources of growth and stability of sectoral output, X, will be presented.

## 3.2 USING DECOMPOSITION TECHNIQUE TO IDENTIFY SOURCES OF GROWTH AND STABILITY

Based on the accounting identities (i.e., material balance equations) presented in equations (3.1) to (3.3), at a point in time a region's economic structure can be depicted by $R_tF_t$, and performance by $X_t$. This is a static presentation of a region's economic structure and performance. In contrast, the growth and stability of sectoral output are, by definition, dynamic concepts. That is, both the growth and stability of sectoral output are measured through intertemporal comparisons of the relationship X = RF.

In Sections 3.3 and 3.4, growth and stability decompositions of the model of a region's economic structure and performance at different points in time will be used to identify proximate sources of growth and stability in sectoral output. This is a comparative statics approach to the analysis of temporal change. Identification of the proximate sources of growth or stability using comparative statics analysis does not indicate that causal relationships have been established. However, the decomposition technique does provide some indication of the direction and magnitude of economic impacts, and can serve as a guide for models that do incorporate behavioral, technological, and institutional relations as well as assumptions about the function of markets. Chenery (1978), and Kubo et al. (1988) provide an overview of growth decompositions, and Offutt and Blandford (1983; 1986) provide an overview of stability decompositions.

The decomposition of growth presented in Section 3.3 is formulated for a deterministic model of the regional economy. However, as will be shown in Section 3.4, the deterministic model used for the decomposition of growth can be extended to a stochastic model, from both conceptual and applied perspectives.

### 3.3 IDENTIFYING SOURCES OF GROWTH OF SECTORAL OUTPUT

The following decomposition of sectoral output growth draws on the decomposition technique proposed by Chenery (1978). In contrast to the study by Chenery (1978), and latter studies that used this decomposition technique (e.g., Feldman et al. (1987); Kubo et al. (1988); Martin and Holland (1991)), the following application is based on an extended input-output model that is closed with respect to households, and induced impacts are disaggregated into the components $p^C$, C, Q, W, and S. This detailed description provides new insights into the relationship between a region's changing economic structure and performance.

A region's economic structure, RF, and performance, X, at time t is:

(3.17)

$$X_t = R_t F_t ,$$

where X, R and F are defined in equations (3.9) to (3.11).

The region's economic structure and performance at time t+1 is:

(3.18)

$$X_{t+1} = R_{t+1} F_{t+1} ,$$

which can be rewritten as:

(3.19)

$$X_{t+1} = R_t F_{t+1} + (R_{t+1} - R_t) F_{t+1} .$$

Subtracting equation (3.17) from equation (3.19), the growth in sectoral output, written in difference equations form, is:

(3.20)

$$X_{t+1} - X_t = R_t F_{t+1} + (R_{t+1} - R_t) F_{t+1} - R_t F_t ,$$

or:

(3.21)

$$X_{t+1} - X_t = R_t (F_{t+1} - F_t) + (R_{t+1} - R_t) F_{t+1} .$$

According to equation (3.21), the change in a region's sectoral output from base period levels will equal the changes in the exogenous final demands pre-multiplied by the base period structural factors, and the changes in the structural factors post-multiplied by terminal period exogenous final demands.

Switching the base and terminal periods in equations (3.19) and (3.20), equation (3.21) can be rewritten as:

(3.22)

$$X_{t+1} - X_t = (R_{t+1} - R_t)F_t + R_{t+1}(F_{t+1} - F_t) \ .$$

Comparing equations (3.21) and (3.22) it can be observed that there is an 'index number problem'. That is, although either R or F can serve as the base period or the terminal period, the results will depend on the specific ordering. This type of index number problem is not unique to economic analysis (e.g., Paasche and Laspeyres indices). One way to rectify the index problem is to use an average of equations (3.21) and (3.22). In the following decomposition of sectoral output the index number is 'solved' by assuming that the structural factors are from the base period, $R = R_t$, and the exogenous final demands are from the terminal period, $F = F_{t+1}$ (and $X = X_{t+1} = R_{t+1}F_{t+1}$). For notational simplicity no time subscripts will be used in the following decomposition equations.

Assuming that equation (3.17) is a continuous function over time, the time derivative can be written in differential equations form as:

(3.23)

$$\Delta X = \Delta RF + R\Delta F \ ,$$

where, for a variable z, dz/dt is denoted by $\Delta z$, and for a matrix Z, dZ/dt is denoted by $\Delta Z$ (which is a matrix of $\Delta z_{ij}$ for the (ij)th element of Z). Hence the differential equation used in equation (3.23) is the continuous time equivalent of the difference equation used in equation

(3.21). The differential equation will be used due to its ease of computation, and its expositional clarity. Detailed notation of the difference equation is found in Martin and Holland (1991).

Substituting equations (3.10) and (3.11) into equation (3.23) gives:

(3.24)

$$\Delta X = \Delta (I - p^{A}A - p^{C}CQWS)^{-1} F + R \Delta (p^{C}CF_{C} + F_{D}) .$$

According to the rules for calculating the derivative of an inverted matrix:

(3.25)

$$\Delta R = -R \Delta (R^{-1}) R.$$

Based on equation (3.25), the first term in equation (3.24), which measures the impact of changes in components of the sectoral output multiplier post-multiplied by the terminal period level of exogenous final demand, can be rewritten as:

(3.26)

$$\Delta (I - p^{A}A - p^{C}CQWS)^{-1} F = -R \Delta (I - p^{A}A - p^{C}CQWS) RF$$

which can be decomposed into the following structural sources of growth of sectoral output:

(3.27)

$$= \Delta RF1 + \Delta RF2 + \Delta RF3 + \Delta RF4 + \Delta RF5 + \Delta RF6 + \Delta RF7 ,$$

where:

ΔRF1 is the impact of change in regional purchase coefficients of intermediate demands:

(3.28)

$$\Delta RF1 = -R (- \Delta p^{A}A) RF = R\Delta p^{A}AX ,$$

ΔRF2 is the impact of change in input-output coefficients:

(3.29)

$$\Delta RF2 = -R\ (-\ p^{A}\Delta A)\,RF = Rp^{A}\Delta AX\ ,$$

ΔRF3 is the impact of change in regional purchase coefficients of household final demands related to induced impacts:

(3.30)

$$\Delta RF3 = -R\ (-\ \Delta p^{C}CQWS)\,RF = R\Delta p^{C}CQWSX\ ,$$

ΔRF4 is the impact of change in household consumption patterns related to induced impacts:

(3.31)

$$\Delta RF4 = -R\ (-\ p^{C}\Delta CQWS)\,RF = Rp^{C}\Delta CQWSX\ ,$$

ΔRF5 is the impact of change in occupation-household relations:

(3.32)

$$\Delta RF5 = -R\ (-\ p^{C}C\Delta QWS)\,RF = Rp^{C}C\Delta QWSX\ ,$$

ΔRF6 is the impact of change in income-occupation coefficients:

(3.33)

$$\Delta RF6 = -R\ (-\ p^{C}CQ\Delta WS)\,RF = Rp^{C}CQ\Delta WSX\ ,$$

and

ΔRF7 is the impact of change in occupation-output coefficients:

(3.34)

$$\Delta RF7 = -R\ (-\ p^{C}CQW\Delta S)\,RF = Rp^{C}CQW\Delta SX\ .$$

The second term in equation (3.24), which measures the impact of changes in exogenous final demands pre-multiplied by the base year levels of components of the sectoral output multiplier, can be decomposed into the following structural sources of growth of sectoral output:

(3.35)

$$R\Delta(p^{c}CF_{C} + F_{D}) = R\Delta F1 + R\Delta F2 + R\Delta F + R\Delta F4 \ ,$$

where:

RΔF1 is the impact of change in regional purchase coefficients of household final demands related to exogenous income:

(3.36)

$$R\Delta F1 = R\Delta p^{c}CF_{C} \ ,$$

RΔF2 is the impact of change in household consumption patterns related to exogenous income:

(3.37)

$$R\Delta F2 = Rp^{c}\Delta CF_{C} \ ,$$

RΔF3 is the impact of change in exogenous income:

(3.38)

$$R\Delta F3 = Rp^{c}C\Delta F_{C} \ ,$$

and

RΔF4 is the impact of change in sectoral final demands:

(3.39)

$$R\Delta F4 = R\Delta F_{D} \ .$$

Below is a discussion of the structural sources of growth in sectoral output. For expositional purposes, some of the impacts presented in equations (3.28) to (3.39) have been combined.

As a diversification strategy, many regions have contemplated policies that promote a widening or deepening of backward-linkages [Rose et al.

(1988)] The widening of linkages is associated with new intersectoral linkages, whereas the deepening of linkages is associated with increases in existing intersectoral linkages. New intersectoral linkages can be achieved by changes in regional purchase coefficients of intermediate demands, $\Delta p^A$ (from $p_i^A=0$ to $p_i^A>0$), or by changes in the input-output coefficients, $\Delta A$ (from $a_{ij}=0$ to $a_{ij}>0$). When $\Delta(p^A A)$ is associated with adding new sectors, zeroes in the region's $p^A A$ matrix are replaced by positive values, which as mentioned in Section 2.6.6, Hirschman (1989) defines as the 'process of diversification'. Increases in existing intersectoral linkages can be achieved by positive changes in $\Delta p^A$, for $p_i^A > 0$, or by $\Delta A$, for $a_{ij} > 0$. Whatever the case, the impacts of $\Delta p^A$ and $\Delta A$ are closely related because A is a matrix of the region's input-output coefficients (where A measures all potential intersectoral relationships), and $p^A A$ measures the degree to which the intersectoral relationships are realized.

### 3.3.1 Impact of Change in Regional Purchase Coefficients of Intermediate Demands

Recalling equation (3.28):

(3.40)

$$\Delta RF1 = R \Delta p^A AX \ .$$

The change in the regional purchase coefficient for intermediate demands, $\Delta p^A$, is post-multiplied by the level of intermediate demands, AX, and pre-multiplied by the sectoral output multiplier, R. For the ith sector, a large regional purchase coefficient, $p_i^A$, represents a higher degree of import substitution (i.e., a lower degree of dependency on imports). That is, a higher $p_i^A$, represents a lower degree of 'leakages' of economic activity from the region.

The change in a given sector's output due to $\Delta p_i^A$ is limited by the sectoral output multiplier, R, by the initial level of $p_i^A$, and by the level of intermediate demands, AX. The expansion or contraction of existing sectoral activity (i.e., deepening of intersectoral linkages) is associated with changes in $0< p_i^A \leq 1$, whereas new sectoral activity (i.e., widening of intersectoral linkages) is associated with changes from $p_i^A = 0$ to $0< p_i^A \leq 1$.

Many regions have contemplated import substitution policies as a diversification strategy [Berck et al. (1989); Gilchrist and St. Louis (1991)]. However, there are valid economic reasons for the $p_i^A$ of a sector being low. Based on regional comparative advantage, it may be economically efficient for a region to import certain intermediate demands instead of producing them locally. Hence, an import substitution strategy should not be based exclusively on the search for low regional purchase coefficients, because it may be counterproductive.

Import substitution strategies should be based on: (i) a thorough analysis of comparative advantage in the production of goods and services earmarked for regional producers (the potential for exporting any surpluses should also be analyzed), and (ii) the market trends for exogenous final demands, since AX is a derived demand based on the level of exogenous final demands.

Import substitution is related to the concept of agglomeration economies, which was discussed in the context of location theory in Section 2.6.5. That is, one aspect of import substitution strategies is the assumption that there will be some agglomeration economies if backward-linked input suppliers are located in the proximity of the purchasing sector.

Different policies can be used to promote increased import substitution. Besides financial subsidies, a region can provide infrastructure, communications, storage, and information services that increase the potential for gains associated with the agglomeration of economic activities in the region.

### 3.3.2 Impact of Change in Input-Output Coefficients

Recalling equation (3.29):

(3.41)

$$\Delta RF2 = Rp^{A}\Delta AX \ .$$

The change in input-output coefficients, ΔA, is post-multiplied by the level of economic activity, X, and then pre-multiplied by factors that influence the degree of leakages and linkages in the regional economy $Rp^{A}$. The changes in input-output coefficients are caused by changes in production technologies, changing prices, and the substitution among various inputs in response to changing relative prices. It is often assumed that changes in input-output coefficients take place slowly over time. This assumption underlies the justification for only periodically updating the database for input-output models.

The change in input-output coefficients, ΔA, can be associated with: (i) changes in productive efficiency, or (ii) substitution among inputs from existing sectors or new sectors. The different sources of ΔA will have different impacts on changes in sectoral output. In any case, it should be emphasized that for the ith sector $\Sigma_i a_{ij} + \Sigma_k v_{kj} = 1$, and $\Sigma_i \Delta a_{ij} + \Sigma_k \Delta v_{kj} = 0$. Changes in the usage of sectoral inputs or factors of production to produce a dollar's worth of the ith sector's output cancel each other out. That is, for a given level of exogenous final demand, if less sectoral inputs are used then there will be higher returns to labor and capital. Changes in payments to backward-linked sectors will have distributional impacts through payments made to sectors for inputs, and payments made to households for their factors of production. These are the indirect impacts. The change in payments made to households will then lead to induced impacts, since $p^A \Delta AX$ is pre-multiplied by R.

For a given vector of exogenous final demand, F, gains in productive efficiency occur when, to produce the ith sector's output, the $\Delta a_{ij}$ for all sectors j is non-positive and negative in at least one sector j. In this case, the impact on sectoral output, $\Delta X_j$, will depend on the distribution of the 'surplus' generated by the gains in productive efficiency. If the surplus is received by the region's residents as payment for their factors of production (e.g., as increased wages or profits) then the overall change in output will depend on whether $p^C C \Delta V$ (where V=QWS) is greater than or equal to $p^A \Delta A$. If a firm adopts a new technology that increases efficiency, but the increased profits go to non-residents, then there might be a decline in sectoral output in the short-run. Hence, there might be short-run negative regional economic impacts associated with efficiency gains. However, in the longer-run, production-related efficiency gains can lead to growth in the region's sectoral output if competitiveness increases, and exogenous final demands rise. Even if the profits resulting from efficiency gains are retained in the region, then the overall change in sectoral output will still depend on whether $p^C C \Delta V$ is greater than $p^A \Delta A$.

The input-output coefficients, A, may also change due to the substitution among inputs. It is possible that inputs produced within the region are substituted for inputs produced outside the region, or vice versa. This substitution of inputs can take place among existing sectors, or might entail new sectors. An example of the substitution of inputs from a new sector is the use of the ingredient 'Simplesse' as a substitute for regionally-produced cream in the regional manufacture of ice cream. There will be distributional impacts among sectors and households, depending on the distribution of payments to backward-linked sectors, and the distribution of payments to factors of production. Clearly the economic impacts will depend on whether 'Simplesse' is manufactured within the region or imported. As was the case of the $\Delta A$ resulting from production-related efficiency gains, the direction and distribution of changes in sectoral output will depend on the substitution among inputs. The magnitude and direction of the impact of substitutions among inputs will depend on the relative linkages and leakages of the substituted sectors, and whether the new production technologies lead to increased competitiveness and increases in exogenous final demands.

Another example of $\Delta A$ is the use of the 'just-in-time' system for managing inventories. The just-in-time system entails the substitution of transportation and communication services for storage services. Hence, it is clear that some individuals and firms will be winners and some will be losers. Once again the regional impacts from this substitution of inputs will depend on the multiplicative relationship the $p_i^A \Delta A$ (the respective regional purchase coefficients of transportation, communication, and storage services), which is post-multiplied by X, and pre-multiplied by R.

These observations have important implications for the design of development strategies based on changing technologies. Increases in productive efficiency and the adoption of new technologies can result in short-run declines in regional economic activity. In addition, there may be significant distributional impacts. In the longer-run these changes should lead to increased competitiveness and economic growth, however the distribution of this growth might lead to either desirable or undesirable outcomes from region-wide and individual perspectives. These observations emphasize the pivotal role of the level of exogenous final demands, F, and changes in exogenous final demands, $\Delta F$. Gains in production efficiency will not necessarily generate increases in sectoral output unless exogenous final demand for that sector grows.

Regions have used different development strategies to facilitate the adoption of new production technologies and to encourage producers to become more efficient by substituting among various inputs. These development strategies usually entail investments in physical and human capital. Investments in infrastructure, including transportation, communication and storage facilities can bring about changes in intersectoral relations and enhance the efficiency of resource use. Investments in education, training, and manpower development can also bring about changes in intersectoral relations and enhance the efficiency of resource use.

### 3.3.3 Impact of Change in Regional Purchase Coefficients of Household Final Demands

Combining equations (3.30) and (3.36):

(3.42)

$$\Delta RF3 + R\Delta F1 = R\Delta p^{C}CQWSX + R\Delta p^{C}CF_{C} .$$

The first term indicates that a change in the regional purchase coefficient for household final demands, $\Delta p^C$, will be post-multiplied by the level of income generated by regional production, WSX, allocated to households according to Q, and spent according to consumption functions C. The induced impacts of regional production by sector, will be CQWSX pre-multiplied by $\Delta p^C$, all of which are then pre-multiplied by the sectoral output multiplier, R. The induced impacts are constrained by the level of sectoral final demands. The second term indicates that $\Delta p^C$ will be post-multiplied by the level of exogenous income, $F_C$, and spent according to consumption functions C.

Like the regional purchase coefficients for intermediate demands, a higher $p_i^C$ is associated with lower leakages. The expansion or contraction of existing sectoral activity are associated with changes in $0< p_i^C \leq 1$, whereas new sectoral activity is associated with changes from $p_i^C=0$ to $0< p_i^C \leq 1$.

Final household demands include a wide range of consumer goods and services. Most non-durable goods and personal services are purchased a short distance from an individual's home. The $p_i^C$ for the retail sectors that provide these goods and services may already be high, especially in large, densely populated regions. In contrast, if the $p_i^C$ are low, as is the case in many rural regions, there might be some potential for import substitution in retail sales and personal services. A retail trade area analysis for a regicn can help identify this potential [Hustedde et al. (1991)].

However, strategies based on the recruitment of different types of retail sales centers, such as shopping malls and chain store outlets, may have a small impact if they are owned by non-residents and/or pay low wages (i.e., the value-added of such activities, W, will be low). Also, they may merely replace existing small-scale resident-owned retail outlets, and may have lower $p_i^A$ than existing outlets (e.g., most chain stores purchase standard supplies from distribution centers outside the region).

The level of income received either as WSX or $F_C$, and residents' consumption functions, C, will affect the potential impacts of changes in the regional purchase coefficients of household final demands, $\Delta p^C$. According to economic theory, consumption patterns are influenced by income levels, and there is a tendency for higher income households to have a lower marginal propensity to consume regional goods and services, due to higher savings rates and expenditure patterns that include more goods and services produced and/or purchased outside the region [Bernat and Johnson (1991)].

Clearly, a region's occupation mix, measured by SX (equation (3.15)), will be a major factor in determining the level of gross income, WSX (equation (3.14)), and its residents' consumption patterns, CQWSX. Hence, industrial recruitment strategies that target certain production-oriented sectors (with a given occupation mix) will have important impacts on consumption-oriented sectors in the region.

In the context of rural regions:

> "The problem is not that [natural] resource industries locate in rural areas; it is the occupational structure of rural industries. Resource industries have a very low percentage of management occupations and professional and technical occupations. This means that the majority of jobs in resource industries are low skilled and low paid [Painton (1991), p.16]."

### 3.3.4 Impact of Change in Household Consumption Patterns

Combining equations (3.31) and (3.36):

(3.43)

$$\Delta RF4 + R\Delta F2 = Rp^{C}\Delta CQWSX + Rp^{C}\Delta CF_{C} \ .$$

The first term relates to household final demands from endogenous income, WSX, and the second term relates to household final demands from exogenous income, $F_C$. Both terms indicate that a change in household consumption patterns, $\Delta C$, is post-multiplied by the respective income levels, and then pre-multiplied by the degree of linkages and leakages in the regional economy, $Rp^C$.

The different consumption patterns of household groups (based on income classes) at a given point in time was discussed above in Section 3.3.3. The consumption patterns of a given household group can change over time due to changes in tastes and preferences, relative prices, and income. It is usually assumed that consumption patterns change slowly over time. However, the proliferation of new electronic and information-based goods and services, and health-related personal goods and services in the 1970's and 1980's illustrates that this assumption may not always be valid.

Regions can try to change consumption patterns by promoting 'desirable' consumption and discouraging 'undesirable' consumption. Strategies that rely on policies such as subsidies, taxes, legal restrictions on certain behavior, zoning regulations, etc. can all be used to modify consumption patterns. The impact of ΔC will depend on the existing income levels and consumption patterns of households (recall C is an element of R), which will be determined, to a large degree, by the occupation mix and income levels of the residents, and the degree of linkages and leakages in the regional economy.

### 3.3.5 Impact of Change in Labor Force Characteristics

Combining equations (3.32), (3.33), and (3.34):

(3.44)

$$\Delta RF5 + \Delta RF6 + \Delta RF7 = Rp^{c}C\Delta QWSX + Rp^{c}CQ\Delta WSX + Rp^{c}CQW\Delta SX \ .$$

The first term measures the impact of changes in occupation-household relations, ΔQ. This includes demographic changes in households that affect labor participation rates (e.g., housewives joining the labor force, individuals on public assistance joining the labor force, retirement decisions). The impact of changes in labor participation rates is calculated by post-multiplying ΔQ by the total wage and capital income based on regional production, WSX, and then pre-multiplying by factors that influence the degree of leakages and linkages in the regional economy $Rp^{C}C$.

Policies that affect labor force participation rates may include the provision of day care facilities, change in eligibility requirements for public assistance, training programs for individuals on public assistance, increasing or lowering the mandatory retirement age, changing eligibility requirements for receiving retirement benefits, and tax policies that increase or decrease real income. These policies are determined at various levels of government, and by the private sector. Hence, they are not policy options for all regions.

Another type of demographic change in households that can affect labor participation rates is migration. Many rural regions have been characterized by the out-migration of younger, better educated and skilled residents, and the in-migration of retirees [USDA (1990a); USDA (1990b)].

The second term in equation (3.44) measures the impact of changes in the income-occupation coefficient, $\Delta W$, where $\Delta W_i$ is the change in value-added received by the ith occupation group. The $\Delta W$ includes changes in wage and capital income that is retained in the region (e.g., wage adjustments, changes in the ownership of factors of production). The $\Delta W$, are post-multiplied by the labor force, SX, and then pre-multiplied by factors that influence the degree of leakages and linkages in the regional economy $Rp^{C}CQ$. Wage adjustments and changes in the ownership of factors of production can be either positive or negative. For example, workers might take a short-term pay cut to prevent layoffs, whereby $\Delta W_i$ is negative, or workers might negotiate a pay raise, whereby $\Delta W_i$ is positive.

Changes in the ownership of firms will lead to changes in the value-added retained in the region. A firm owned by a regional resident that is purchased by a firm located outside the region can lead to a downturn in regional value-added.

For some regions a development strategy is to reduce the leakage of value-added may be to encourage non-resident recipients of this value-added to relocate into the region. For example, extra-regional owners of property or in-commuters may be encouraged to relocate into the region if the quality of public services is improved.

The residency of owners of firms located in the region is a particularly relevant issue for natural resource-based sectors (Berck et al. (1989); Painton (1991); Rose et al. (1988)). In the agriculture sector there is a high proportion of farms that are owned and operated by residents. However, firms in the mining, forestry, and fishing sectors (especially large capital-intensive firms) tend to be owned by non-residents. In addition, in contrast to the agricultural sector, these resource extractive sectors tend to have a low degree of linkages to the regional economy. So, for a dollar's worth of final demand received by these resource extractive sectors, only a very small proportion contributes to regional income and employment. For this reason it is critical to analyze the income and employment impacts of sectoral final demands, and not to focus attention on a sector's gross export revenues.

The third term in equation (3.44) measures the impact of changes in the occupational-output coefficient, $\Delta S$, a change in the occupation mix used to produce sectoral outputs. This includes the substitution of one occupation group for another, or the substitution of capital for labor or vice versa. The $\Delta S$ will result from resource constraints, substitution of factors of production in response to changing relative prices, or technological change. The change in occupation-output coefficients, $\Delta S$, is post-multiplied by the level of sectoral output, X, to measure the change in labor demand by occupation group, $\Delta SX$, and then pre-multiplied by the income-occupation coefficient, W, to measure the change in the region's total wage and capital income, $W\Delta SX$. The change in the region's wage and capital income are then pre-multiplied by factors that influence the degree of leakages and linkages in the regional economy $Rp^{C}CQ$. Regions with a high degree of unemployed laborers in a specific occupation group may provide firms with incentives to change their occupation mix or labor-capital ratios in favor of the unemployed laborers. In contrast, industrial recruitment strategies based on reducing unemployment by increasing sectoral final demands are addressed in the context of $R\Delta F_D$ which is discussed in Section 3.3.7, not $\Delta SX$.

It should be emphasized that any development strategy may (and, in many cases will) consist of more than one source of sectoral output growth. In this section the sources of growth have been addressed individually for expositional purposes. For example, an industrial recruitment strategy may combine incentives for a sector to adjust the occupation mix to target certain occupations for reductions in unemployment, while simultaneously striving for an increased level of exports (i.e., increased sectoral final demands, $F_D$) that would increase total regional employment (and, returns to capital). Combining equations (3.34) and (3.37), the impact of this strategy on change in sectoral output could be measured as:

(3.45)

$$\Delta X = Rp^{C}CQW\Delta SX + R\Delta F_D \ .$$

In many sectors higher-skilled laborers are replacing lower-skilled laborers, or higher-skilled labor and capital are being substituted for lower-skilled labor. The educational system, training programs, and other manpower development programs can help the labor force adjust to changing economic conditions. However, it should be noted that investments in human capital are risky, because better skilled labor may out-migrate if there are no appropriate employment opportunities in the region. Strategies based on regional investments in human capital should be planned in conjunction with industrial targeting and recruitment strategies.

Furthermore, since labor requirements for a given level of output tend to decrease over time, ΔS can exert a negative impact on total employment, SX. If associated with gains in productive efficiency, the decrease in labor requirements can be offset by increases in exogenous final demands. In all cases of ΔS, it is important to analyze the distributional impacts on regional employment, because different occupation groups might gain or lose jobs.

#### 3.3.6 Impact of Change in Exogenous Income

Recalling equation (3.36):

(3.46)

$$R\Delta F3 = Rp^{c}C\Delta F_{C} \ .$$

The change in income from exogenous sources includes changes in transfer payments, income received by out-commuters, and returns on residents' assets held outside the region. The change in exogenous income is pre-multiplied by factors that influence the degree of leakages and linkages in the regional economy $Rp^{c}C$. A popular strategy is to promote increases in the receipt of such exogenous income flows.

An example of a development strategy based on the receipt of exogenous income is the creation of retirement communities. The attraction of retirees has become a 'big business' for many rural regions [USDA (1990a); USDA (1990b)]. In this case, social security payments and other retirement income are a source of increases in sectoral output. The impact of retirement communities will depend on the retirees' income, $F_C$, consumption patterns, C, the amount of goods and services they purchase locally, $p^C$, and the region's sectoral output multiplier, R. For a region with a low degree of intersectoral linkages and limited retail sales outlets, the economic impact of changes in exogenous income from retirees may be small.

During the era of 'New Federalism', which began in the early 1980's, many regions have suffered from a reduced flow of transfer payments from the federal government to local governments and individuals. As may be expected, this has had a negative impact on many regions, notably rural regions which tend to receive considerable amounts of welfare-related transfer payments, and commodity supports [Kraybill (1989), p.6]. In addition, New Federalism has led to a reduced flow of transfers to regional governments for welfare, education, and infrastructure.

Another important impact of the era of New Federalism is the heightened demand by regions for the type of research presented in this study. There has been a process of decentralization of economic and political responsibility that places the onus on regions to chart their own economic future. That is, for many economically distressed regions, the once outstretched hand of government is now a tight fist. As such, more and more regions are realizing the need for an improved conceptual and analytical framework to better understand past and present economic developments, and to better plan for the future.

### 3.3.7 Impact of Change in Sectoral Final Demands

Recalling equation (3.37):

(3.47)

$$R\Delta F4 = R\Delta F_D \ .$$

This is the traditional focus of economic impact analysis, whereby the 'engine' of the regional economy is assumed to be $F_D$. Using a standard closed input-output model, which assumes that the structural factors do not change during the period of analysis, the economic impacts of changes in exports, government demand for regionally produced goods and services, and investment outlays by regional producers, can be calculated using equation (3.47). In this context, equation (3.47) can be considered a projection model based on changes in sectoral final demands. In the operational model presented in Chapter 4, the growth in regional income and employment are calculated by combining equations (3.47) and (3.46). That is, the operational model is a projection model based on changes in exogenous final demands, $\Delta F$.

In many cases the term sectoral final demands is associated almost exclusively with interregional and international exports. Hence, many regional development strategies are, in reality, export promotion strategies. The change in exports can result from an expansion or contraction in the level of existing export activities or from new export activities.

The attraction of additional export activities is the predominant strategy for many regions. The targeting and recruitment of new export activities will depend on the resource base of the region, including the occupation mix of the labor force.

As mentioned previously, in practice, many development strategies consist of several sources of sectoral output growth. Another example is a 'value-added strategy', which is sometimes referred to as a type of 'diversification strategy' [Kraybill and Johnson (1989)]. For a rural region, a value-added strategy may entail the reduction of exports of unprocessed natural resources (i.e., a decline in sectoral final demands from the ith sector $\Delta F_{Di}<0$), and an increased purchase of the ith sector's output as an intermediate demand for some of the j sectors (e.g., food manufacturing, furniture making), $\Delta p_i^A>0$. Then, the processed goods are exported by the j sectors. This process of simultaneously reducing exports and increasing intersectoral linkages may lead to increases in value-added retained in the region as an indirect impact, and as an induced impact. This is an example of widening or broadening intersectoral linkages, which may also include $\Delta A$. In the case of $\Delta A$, investment in infrastructure may lead to changes in input-output coefficients. The impact of a value-added strategy will depend on the degree of intersectoral linkages and leakages, and the distribution of value-added, wage and capital income, among residents and non-residents.

Combining equations (3.28), (3.29), and (3.39), the impact of a value-added strategy on change in sectoral output could be measured as:

(3.48)

$$\Delta X = R\Delta p_i^A AX + Rp^A \Delta AX + R\Delta F_{D_i}.$$

Many rural regions have been characterized by the declining economic contribution of traditional natural resource sectors such as farming, forestry, mining, and fishing, and the increasing economic contribution of natural resource amenity sectors such as recreation and tourism, retirement communities, and second homes. Hence, natural resource sectors are no longer based on the export of 'raw materials', but on creation of value-added based on the amenity value of 'unprocessed' natural resources (i.e., environmental quality). As such, economic activities associated with natural resource amenities can also be conceptualized as examples of value-added strategies [NCRI (1990)]. In the manner of equations (45) and (48), alternative development strategies can be conceptualized using the growth decomposition presented in this section.

Sectoral final demands, which are gross revenues received by producers, can be decomposed into price and quantity components:

(3.49)

$$\Delta F_D = (\Delta PRICE)(QUANT) + (PRICE)(\Delta QUANT) ,$$

where PRICE and QUANT are nxn diagonal matrices of prices and quantities, respectively.

When analyzing a change in sectoral final demands it may be important to know whether the source of change is price-based or quantity-based. This information is especially important when evaluating the past growth and stability of sectoral final demands, and when forecasting their growth and stability. For example, if changes in export demand are price-based, (ΔPRICE)(QUANT), then a constant quantity of exports will result in changes in value-added due to higher wage and capital income (and associated induced impacts). In contrast, if changes in export demand are quantity-based, (PRICE)($\Delta$QUANT), then an increased quantity of exports will result in both indirect impacts (due to increased production activity), and induced impacts. Since a standard input-output model is a fixed-price model, it is assumed that changes in final sectoral demands are generated by (PRICE)($\Delta$QUANT).

Besides the formulation of a comprehensive conceptual and analytical framework, accurate forecasts of the growth and stability of sectoral final demands are the most critical aspect of evaluating alternative development strategies. A discussion of the appropriate statistical methods for modelling this growth and stability, and for decomposing them into price and quantity components is beyond the scope of this study. Offutt and Blandford (1983; 1986) provide overviews, and Ali et al. (1991) and Hazell et al. (1990) provide examples of some statistical methods that can be used to model the growth and stability of exports.

Changes in interregional and international exports reflect changes in national and international markets, and in regional competitiveness. It is assumed that changes in exports are related to changes in national and international markets, and that changes in regional competitiveness are related to changes in structural factors. The impacts of changes in the structural factors ($\Delta p^A$, $\Delta A$, $\Delta p^C$, $\Delta C$, $\Delta Q$, $\Delta W$, $\Delta S$) are assumed to be constrained by the level of a region's exogenous final demands ($F_D$ and $F_C$). In contrast, the changes in exogenous final demands, $\Delta F$ are assumed to be constrained only by the size of the market. That is, it is assumed that there are no resource constraints that constrain the change in sectoral output when there are changes in sectoral final demands, $\Delta F_D$. When using an operational model without explicit resource constraints the practitioner should impose implicit resource constraints in order to make realistic projections.

The shift-share technique, which was described in Section 2.6.1, is an identity-based decomposition that can be used to decompose sectoral output growth into the relative contributions of: (i) national and international market trends, (ii) a region's sectoral mix, and (iii) a region's competitiveness. The shift-share technique is useful because it provides a conceptual framework to distinguish between secular trends in sectoral final demands, and region-specific trends. Hence, the shift-share technique can be used to help identify alternative export or import substitution strategies.

### 3.3.8 Recent Studies that Used the Growth Decomposition Technique

Some recent studies have used the growth decomposition technique to identify, *ex post*, the sources of changes in sectoral output for the United States. These studies used open input-output models based on material balance equations of national input-output accounts.

Feldman et al. (1987) find that from 1963 to 1978 changes in exogenous final demands contribute to most of the change in sectoral output. The exceptions are the most rapidly growing and the most rapidly declining sectors, in which changing structural factors are major sources of change in sectoral output. The authors explain that changes in sectoral output for rapidly growing and declining sectors are due mostly to changing input-output coefficients, $\Delta A$. That is, intersectoral linkages change as the expanding (contracting) sectors' output is used more (less) by other sectors.

Martin and Holland (1991), who focus their analysis on agricultural sectors, find that from 1972 to 1977 changing structural factors contribute to most of the change in the output of agricultural sectors. This is in contrast to non-agricultural sectors for whom changing exogenous final demands are the major source of changing sectoral output. Since many agricultural sectors were characterized by rapid growth or decline during the 1972-1977 period, their results concur with those of Feldman et al. (1987) who attribute most of the changes in sectoral output to changes in exogenous final demands.

In a chapter in the book Frontiers of Input-Output Analysis, Blair and Wyckoff (1989) analyze the changing structure of the U.S. economy from 1972 to 1984. They emphasize the importance of using a decomposition technique that can analyze changes in both the sectoral output multiplier and exogenous final demands. They criticize past studies of changing economic structure as merely being multiplier analyses. They point out that many purported studies of changing economic structure focus attention on the multiplier and ignore the multiplicand, that is, exogenous final demands. Like the conceptual framework presented in this study, they define structural change as temporal variations in the magnitude and composition of sectoral output that result from the multiplicative relationship of changes in exogenous final demands and the sectoral output multiplier.

All of these studies use the growth decomposition technique for *ex post* analyses which, by nature, assumes a deterministic model of a regional economy (that is, the outcomes are already known with certainty). In contrast, in this section the growth decomposition technique is used to provide a conceptual framework for an *ex ante* analysis which, by nature, should be based on a stochastic model of a regional economy (the future outcomes are not known with certainty). The next section will demonstrate the close relationship between the deterministic and stochastic models of sectoral output growth. It will be shown that, with some notational and conceptual adjustments, the stochastic terms 'expected change' and 'expected growth' can replace the deterministic terms 'change' or 'growth' used in this section.

### 3.4 IDENTIFYING SOURCES OF STABILITY IN SECTORAL OUTPUT

In this section a decomposition technique is used to identify the sources of stability in sectoral output. The decomposition of the growth of sectoral output can be based on either a deterministic or stochastic model of the regional economy. Decomposition of stability of sectoral output is, by definition, based on a stochastic model of the regional economy.

In reality, X is a vector of means from a distribution that is an identity function of the matrix of stochastic variables R and the vector of stochastic variables F. That is, $X_t = R_tF_t$ is a dynamic process for which there is a discrete sequence of observations (see Spanos (1986), Chapter 8, for a discussion of stochastic processes). Hence, a probability model of regional economic structure and performance should be used.

This section models the dynamic aspects of regional economic structure and performance, using the first two moments of $X_t = R_tF_t$. The first moment, the mean $E[X_t] = E[R_tF_t]$ measures the expected value of the stochastic variables, and the second moment, the variance

$VAR[X_t] = VAR[R_tF_t]$ measures the squared deviation of the observed minus the expected values of the stochastic variables.

For a given period t, the expected growth of sectoral output, $\Delta X$, is defined as:

(3.50)

$$E[\Delta X] = E[X_{t+1}] - E[X_t],$$

where $E[\Delta X]$ is a stochastic variable written in difference equation form. This is a stochastic version of the deterministic equation of sectoral output growth presented in equations (3.20) to (3.22). In Section 3.3 the notation $\Delta X$ was used to denote the time derivative in a differential equation. In this section the notation $\Delta X$ denotes the growth in sectoral output using difference equation form (i.e., discrete time). This switch to difference equation form is based on computational ease, and expositional clarity. As will be shown, references to $E[\Delta X]$ in this section are applicable to the previous section, as are references to $E[X]$, $E[R]$, and $E[F]$. That is, the previous section can also be conceptualized in terms of a stochastic process.

The stability of sectoral output is defined by:

(3.51)

$$VAR[X] = \frac{1}{T_*} \sum_{t=1}^{T_*} (X_t - E[X_t])(X_t - E[X_t])^T,$$

where $T_*$ is the number of periods in the data series, and the superscript T denotes a transpose.

The following model of a region's economic structure and performance can be referred to as 'probabilistic' input-output modelling, in contrast to 'stochastic' input-output modelling. This distinction between probabilistic and stochastic input-output modelling is made by Jackson (1989). He claims that the primary interest of past research was stochastic input-output modelling--analysis of the accuracy of estimates of input-output coefficients for a given point in time (the type of random, systematic error structures resulting from the measurement, sampling, aggregation, etc. of data) [Jackson (1989), p.87]. In contrast, he suggests that there is a need for research on probabilistic input-output modelling--analysis of the dynamically generated stochastic variables that constitute a region's economic structure and performance.

It is important to point out a linkage that exists between stochastic and probabilistic input-output modelling. Stochastic input-output modelling focuses attention on data issues, of which errors due to the aggregation of non-identical firms into sectors and individuals into household groups are critical. Probabilistic input-output modelling focuses attention on the uncertainty that characterizes economic relationships.

A major source of uncertainty in economic relationships is the heterogeneity among firms within sectors and among individuals within household groups. That is, although firms within a sector and individuals within a household group might indeed have a great deal in common, it is the differences among them that contribute to some of the uncertainty observed in economic relationships. These differences can actually have a stabilizing impact on regional economic activity, because each component of E[X], E[R], and E[F] is itself a distribution of outcomes [Powell et al. (1990)].

To provide a better understanding of the process of change in a region's economic structure and performance, this section presents a method for decomposing the variance of the vector of stochastic variables X, into components that can be associated with the separate stochastic variables in the accounting identity, X = RF, and interactions among them. The decomposition technique is conceptually similar to that proposed by Burt and Finley (1968) for decomposing the variance of a stochastic variable that is an identity function of a multiplicative relationship between stochastic variables. However, in this case the multiplicative relationship is between a matrix of stochastic variables and a vector of stochastic variables, which requires special notation and interpretation [Terrell (1991)].

### 3.4.1 Calculating the Expected Value

The sectoral output multiplier can be expressed as a nxn matrix of stochastic variables:

(3.52)

$$R_t = \mu_R(t) + \varepsilon_R(t) \ ,$$

where:

$\mu_R(t)$ = nxn matrix of the means of the components of the sectoral output multiplier at time t, and

$\varepsilon_R(t)$ = nxn matrix of deviations from the mean of the components of the sectoral output multiplier at time t.

By definition, $E[R_t] = \mu_R(t)$ and $E[\varepsilon_R(t)] = \{0\}$, where {0} denotes a nxn matrix of zeroes.

The expectation of the stochastic matrix E[R] is defined as the nxn matrix of expectations $(E[R_{ij}])$ for i=1,...,n and j=1,...,n. The ith row of the matrix is: $(E[R_{ij}]) = (E[R_{i1}], E[R_{i2}], \ldots, E[R_{in}])$.

The sectoral output multiplier, R, is an inverse. The question arises whether the expected value of the inverse should be calculated, or the inverse of the expected value of the components of R. In theory the stochastic sectoral output multiplier matrix should be estimated by E[R], but in practice it is only possible to estimate it by $(I - E[p^A A - p^C CQWS])^{-1}$ (which was used for the decomposition of growth in Section 3.3). The distinction between calculating either E[R] or $(I - E[p^A A - p^C CQWS])^{-1}$ is not trivial because the results are different [Simonovits (1975)]. In the following decomposition of stability, for notational compactness, E[R] and VAR[R] are used. This presentation focuses attention on conceptual issues, and there is no attempt to physically measure the variance, which is very cumbersome to derive analytically [Park et al. (1981)].

Sectoral final demands can be expressed as a nx1 vector of stochastic variables:

(3.53)

$$F_t = \mu_F(t) + \varepsilon_F(t),$$

where:

$\mu_F(t)$ = nx1 vector of the means of sectoral final demands at time t, and

$\varepsilon_F(t)$ = nx1 vector of deviations from the mean of sectoral final demands at time t.

By definition, $E[F_t] = \mu_F(t)$ and $E[\varepsilon_F(t)] = \{0\}$. where {0} denotes nx1 vector of zeroes.

Based on equations (3.52) and (3.53) the vector of stochastic variables X can be calculated as:

(3.54)

$$X_t = (\mu_R(t) + \varepsilon_R(t))(\mu_F(t) + \varepsilon_F(t)),$$

which gives:

(3.55)

$$X_t = \mu_R(t)\mu_F(t) + \mu_R(t)\varepsilon_F(t) + \varepsilon_R(t)\mu_F(t) + \varepsilon_R(t)\varepsilon_F(t) \ .$$

It is assumed that $\varepsilon_R(t)$ and $\varepsilon_F(t)$ are small relative to $\mu_R(t)$ and $\mu_F(t)$, and that the term $\varepsilon_R(t)\varepsilon_F(t)$ is small enough that it can be ignored. Hence, the vector of stochastic variables $X_t$ can be approximated by:

(3.56)

$$X_t \doteq \mu_R(t)\mu_F(t) + \mu_R(t)\varepsilon_F(t) + \varepsilon_R(t)\mu_F(t) \, .$$

This result is similar to using a first-order Taylor series expansion as a linear approximation of the value of a stochastic variable that is a product of two stochastic variables. Burt and Finley (1968) calculated a second-order Taylor series expansion and then used the first-order terms in the decomposition of stability, based on the assumption that these generated the relevant terms for economic analysis (the equivalent of which is presented below in equation (3.83)).

The expected value of X in period t can be written as:

(3.57)

$$E[X_t] = \mu_R(t)\mu_F(t)$$

because $E[\varepsilon_R(t)]=\{0\}$, and $E[\varepsilon_F(t)]=\{0\}$. The expected value of sectoral output is a function of the expected values of the sectoral output multiplier and the exogenous final demands. According to equation (3.57) the means are assumed to be time variant.

If the means are time invariant, then:

(3.58)

$$E[X_t] = \mu_R \mu_F \ .$$

It is possible that one of the stochastic variables has a time invariant mean and the other has a time variant mean. For example, if the mean of R, the regional sectoral output multiplier is time invariant, and the mean of F, the region's exogenous final demands is time variant, then:

(3.59)

$$E[X_t] = \mu_R \mu_F(t) \ .$$

If it is assumed that, based on the data, equation (3.59) accurately depicts the expected values of R and F, respectively, the expected value of sectoral output can be calculated using a time variant trend value for $E[F_t]$, and a time invariant constant value for $E[R_t]$. For computational purposes, using a constant value mean for R is equivalent to a using a fixed sectoral output multiplier. Recall that the standard input-output model assumes the sectoral output multiplier is fixed for the period of analysis, and all changes in sectoral output are attributed to changes in exogenous final demands. Hence, the standard deterministic input-output model is conceptually similar to a stochastic input-output model whereby the expected value of the sectoral output multiplier is time invariant, and the expected value of exogenous final demand is time variant.

In this case, the expected growth in sectoral output can be written as:

(3.60)

$$E[\Delta X] = E[R]\,E[\Delta F] = R\,E[\Delta F] \ .$$

Based on the assumption of a time invariant mean for R, and a time variant mean for F, this is a stochastic version of the deterministic equations that were used in the previous section for measuring the impact of changes in exogenous final demands on the growth of sectoral output. Hence, based on equations (3.46) and (3.47) in Section 3.3, equation (3.60) can be rewritten as:

(3.61)

$$E[\Delta X] = Rp^{C}C\Delta F_{C} + R\Delta F_{D} \ .$$

As can be observed from equation (3.61), the stochastic version of the standard input-output model does not account for temporal changes in structural factors. That is, this stochastic version of a standard input-output model is a projection model that assumes fixed structural factors. In this case, to model temporal changes in structural factors, it is necessary to adjust the base year coefficients.

Based on alternative development strategies, different assumptions about changes in the structural factors can be used to calibrate the base year model, $X_t = R_t F_t$. Then equations (3.60) or (3.61) can be used to measure expected changes in sectoral output. This is the approach used for the operational model presented in Chapter 4. The detailed decomposition of growth presented in Section 3.3 indicates, to some degree, the information that is 'lost' when it is assumed that R is fixed.

The time invariant mean is actually a special (i.e., restrictive) case of the time variant mean. In the remainder of this section the time invariant mean is used in order to minimize notational requirements. However, conceptually there is no such restriction on the trend.

### 3.4.2 Calculating the Variance

The variance of sectoral output is, by definition:

(3.62)

$$VAR[X] = E[(X - \mu_R\mu_F)(X - \mu_R\mu_F)^T] \ .$$

The stability of sectoral output is defined as the squared deviations between observed and expected values of the sectoral output multiplier and exogenous final demands. That is, the expected value of the sectoral output multiplier and exogenous final demands, measured by their respective (time variant or invariant) mean is assumed to be the norm by which 'perfect stability' is measured. Information on the temporal change in the expected value of the sectoral output multiplier and exogenous final demands (which is positive or negative for a time variant mean, and zero for a time invariant mean) is critical for understanding both the growth and stability of sectoral output. Unfortunately, many of the past studies on regional economic diversification have focused attention on the deviations between observed and expected values and ignored their time paths. Hence, sectors with stable and declining output (negative trends) were not distinguished from sectors with stable and increasing output (positive trends).

In the following exposition the time subscripts are ignored for notational compactness. Substituting the X in equation (3.56) into equation (3.62), and simplifying, the variance of sectoral output can be expressed as:

(3.63)

$$VAR[X] = E[(\mu_R e_F + \varepsilon_R \mu_F)(\mu_R e_F + \varepsilon_R \mu_F)^T] ,$$

which equals:

(3.64)

$$VAR[X] = V_1 + V_2 + V_3 + V_4 ,$$

where:

(3.65)

$$V_1 = E[\mu_R e_F e_F^T \mu_R^T] ,$$

(3.66)

$$V_2 = E[\varepsilon_R \mu_F \mu_F^T e_R^T] ,$$

(3.67)

$$V_3 = E[\mu_R e_F \mu_F^T e_R^T] ,$$

and

(3.68)

$$V_4 = E[\varepsilon_R \mu_F e_F^T \mu_R^T] .$$

Next, equations (3.65) to (3.68) are rewritten. First, $V_1$ is rewritten as:

(3.69)

$$V_1 = \mu_R \; E[\varepsilon_F e_F^T] \, \mu_R^T$$

which gives:

where VAR[F] is a nxn variance-covariance matrix of sectoral final

(3.70)

$$V_1 = \mu_R VAR[F] \mu_R^T ,$$

demands. VAR[F] is pre- and post-multiplied (i.e., weighted) by the expected value of the sectoral output multiplier. The (ij)th element of $V_1$ can be written as:

(3.71)

$$V_1(ij) = \mu_{R_i} VAR[F] \mu_{R_j}^T ,$$

where $\mu_{Ri}$ and $\mu_{Rj}$ are the ith and jth rows of $\mu_R$.

Second, $V_2$ is evaluated element-by-element. The (ij)th component of $V_2$ can be expressed as:

(3.72)

$$V_2(ij) = E[\varepsilon_R \mu_F \mu_F^T \varepsilon_R^T]_{ij} ,$$

and

(3.73)

$$V_2(ij) = E[(\varepsilon_{R_i} \mu_F)(\mu_F^T \varepsilon_{R_j}^T)] ,$$

where $\varepsilon_{Ri}$ and $\varepsilon_{Rj}$ are the ith and jth rows of $\varepsilon_R$. Since $\varepsilon_{Ri}$ is a 1xn vector and $\mu_F$ is a nx1 vector, their product is a scalar.

The order of scalars can be rearranged, so that:

(3.74)

$$E[(\varepsilon_{R_i} \mu_F)(\mu_F^T \varepsilon_{R_j}^T)] = E[(\mu_F^T \varepsilon_{R_i}^T)(\varepsilon_{R_j} \mu_F)]$$

which gives the desired notation:

(3.75)

$$V_2(ij) = \mu_F^T E[\varepsilon_{R_i}^T \varepsilon_{R_j}] \mu_F ,$$

or

(3.76)

$$V_2(ij) = \mu_F^T \, COV[R_i, R_j] \, \mu_F \ ,$$

where $R_i$, and $R_j$ are the ith and jth rows of R.

Each (ij)th scalar element of the nxn variance-covariance matrix $V_2(ij)$ is a variance-covariance matrix of the ith and jth row vectors of the sectoral output multiplier matrix pre- and post-multiplied by the vector of sectoral final demands.

Third, $V_3$ and $V_4$ will be rewritten, so that the interaction terms between the sectoral output multiplier, R, and sectoral final demands, F, can be derived. Components $V_3$ and $V_4$ are also evaluated element-by-element. The (ij)th element of $V_3$ can be expressed as:

(3.77)

$$V_3(ij) = E[\mu_R \varepsilon_F \mu_F^T \varepsilon_R^T]_{ij} \ ,$$

and rearranged as:

(3.78)

$$V_3(ij) = E[(\mu_{R_i} \varepsilon_F)(\varepsilon_{R_j} \mu_F)] \ ,$$

which gives the desired notation:

(3.79)

$$V_3(ij) = \mu_{R_i} \, E[\varepsilon_F \varepsilon_{R_j}] \, \mu_F \ ,$$

or

(3.80)

$$V_3(ij) = \mu_{R_i} \, COV[F, R_j] \, \mu_F \ .$$

That is, each (ij)th scalar element of the nxn covariance matrix $V_3[ij]$ is a covariance matrix composed of a multiplicative relationship between the vector of deviations in sectoral final demands and the jth row vector of deviations in the sectoral output multiplier matrix. The covariance matrix is, in turn, pre-multiplied by the ith row vector of the sectoral output multiplier matrix and post-multiplied by the vector of sectoral final demands. Component $V_3$ is the first of two interaction terms that reflect the covariance between the sectoral output multiplier and sectoral final demands. The second interaction term is $V_4$.

$V_4$ is the transpose of $V_3$, so that:

(3.81)

$$V_4(ij) = \mu_F^T E[\varepsilon_{R_j}^T \varepsilon_F^T] \mu_{R_i}^T ,$$

or

(3.82)

$$V_4(ij) = \mu_F^T COV[R_j^T, F^T] \mu_{R_i}^T .$$

Finally, the variance (i.e., stability) of the output of sectors i=1,...,n is the diagonal of the variance-covariance matrix, VAR[X]. The variance of the ith sector, which is an element of VAR[X], can be written by combining equations (3.71), (3.76), (3.80), and (3.82), such that:

(3.83)

$$VAR[X]_{ii} = \mu_{R_i} VAR[F] \mu_{R_i}^T + \mu_F^T COV[R_{ii}] \mu_F + 2\mu_{R_i} COV[F, R_i] \mu_F .$$

### 3.4.3 Decomposing the Variance

Referring to the three terms in equation (3.83) as D1, D2 and D3, respectively, the stability of sectoral output for the ith sector can be decomposed into: D1, the variance of sectoral final demands of all n sectors weighted by the expected value of the ith row of the sectoral output matrix, the elements of which are the intermediate demands by all n sectors for the ith sector's output; D2, the variance of intermediate demands by all n sectors for sector i's output weighted by the expected value of all n sectors' final demands; and D3, two times the covariance between deviations of all n sectors' final demands, and the deviations in intermediate demands by all n sectors for the ith sector's output, weighted by the expected value of all n sectors' final demands and the expected value of intermediate demands by all n sectors for sector i's output. The last term can be written as it is because $COV[F,R_i]$ is symmetric and equal to $COV[R_i^T,F^T]$.

This decomposition of the variance of sectoral output provides several insights into regional economic stability. Below are some general observations, which are then followed by more detailed descriptions of some of the interrelationships between the stochastic variables.

(1) For a fixed sectoral output multiplier and variable exogenous final demands, that is, if R is assumed to be deterministic and F stochastic, then D2=D3=0 and the stability of sectoral output is determined by D1, the weighted variance-covariance of exogenous final demands. As was mentioned previously, standard input-output models assume a deterministic sectoral output multiplier, and are based on projections of exogenous final demands. Hence, assuming R is deterministic:

(3.84)

$$E[X] = R\,E[F] \ ,$$

and

(3.85)

$$VAR[X] = R\ VAR[F]\ R^T .$$

Equations (3.84) and (3.85) can be considered a probabilistic version of the standard input-output model. The operational model presented in Chapter 4 is based on equations (3.84) and (3.85).

As was shown in equations (3.59) to (3.61), it is possible to relax the assumption about R being deterministic in equation (3.84). It is possible to assume that R is stochastic and has a time invariant mean. In contrast, to calculate equation (3.85) requires the more restrictive assumption that the mean of R is, indeed, deterministic. If both R and F are stochastic and not independent then the terms D2 and D3 should also be calculated.

(2) If exogenous final demands are assumed to be deterministic and R stochastic, then D1=D3=0 and the stability of the ith sector's output is determined by D2, the weighted variance of intermediate final demands by all n sectors for the ith sector's output. Once exogenous final demands for all n sectors are set, then it is the stability of the intermediate demands by the n sectors for the ith sector's output that determine the ith sector's stability.

(3) If either the sectoral output multiplier or the sectoral final demands are assumed to be deterministic, then the covariance term, D3, equals zero. In the case where both R and F are stochastic, then D3 represents the process that takes place in regional economies whereby production, consumption, and trade relationships are adjusted to counteract deviations from the expected values of components of the sectoral output multiplier and components of exogenous final demands,

respectively. Hence, D3 reflects the ability of a region to moderate the impacts of instability caused by fluctuations in exogenous final demands, D1, or instability attributed to fluctuations in components of the sectoral output multiplier, D2.

The covariances can stabilize a region's sectoral output if the different sectoral outputs are negatively correlated, or increase instability if they are positively correlated (or have no impact on stability if they are uncorrelated). The adjustments and stabilizers observed in a regional economy are not necessarily planned. They can result from the natural relationships between variables which occur during cyclical swings in economic activity. The existence of natural relationships between variables underlies the use of various economic indicators. The use of 'leading', 'coincident', and 'lagging' indicators are widely used for forecasting business cycles. The respective indicators refer to statistical series that either tend to lead, coincide, or lag behind the general movement of economic activity [Peterson (1988), p.724].

Instead of measuring the variance and covariance terms in equation (3.83), a few observations will be made about the variance of sectoral final demands, $F_D$, and the covariance of sectoral final demands with structural factors ($p^A$, A, $p^C$, C, Q, W, S), and exogenous income ($F_C$). This focus does not imply that the other variance and covariance terms are not important. Instead, this is an attempt to demonstrate the importance of variance and covariance terms in an analysis of regional economic stability.

The following discussion draws upon past empirical studies and principles of economic theory. As such, the discussion should be considered a presentation of hypothesized relationships. These hypothesized relationships require region-specific empirical testing.

#### 3.4.3.1 Covariance Between Regional Purchase Coefficients and Sectoral Final Demands - $COV[p^A, F_D]$, and $COV[p^C, F_D]$

The covariance between the regional purchase coefficients of intermediate demands and household final demands will be considered together. Past studies that focus attention on the stochastic nature of individual structural factors have noted that regional purchase coefficients tend to be the most variable of all the structural factors [Giarratani and Garhart (1991)]. Indeed, there seems to be ample evidence of a strong negative correlation between sectoral final demands and regional purchase coefficients.

If sectoral final demands are expanding then regional purchase coefficients might decline due to capacity constraints, although the sectoral output associated with import substitution might be increasing (i.e., a smaller coefficient multiplied by a larger multiplicand). In contrast, when sectoral final demands are contracting, excess capacity might allow for increased import substitution, which would increase regional purchase coefficients. According to these examples, the covariance between fluctuations in regional purchase coefficients and sectoral final demands will tend to stabilize the regional economy. Whether sectoral final demands are increasing or decreasing, the relative contribution to stability in sectoral output from the variations in regional purchase coefficients will be constrained by the level of sectoral final demands. This is because, as pointed out in Sections 3.3.1 and 3.3.2, the impacts of $\Delta p^A$ and $\Delta p^C$ are related to indirect and induced impacts, respectively.

#### 3.4.3.2 Covariance Between Input-Output Coefficients and Sectoral Final Demands - COV[A, $F_D$]

In general, input-output coefficients change slowly over time and do not vary much from period-to-period. Exceptions, are severe price shocks, whereby purchases from backward-linked sectors are adjusted. These shocks can result from intersectoral production activities (within the A matrix) or from fluctuations in sectoral final demands. In either case, the variation of input-output coefficients should have a stabilizing impact on the regional economy, because they tend to move in a countercyclical direction to the shock.

#### 3.4.3.3 Covariance Between Household Consumption Patterns and Sectoral Final Demands - COV[C, $F_D$]

For some sectors, there tends to be a positive correlation between fluctuations in household consumption patterns and fluctuations in sectoral final demands. This is one of the basic tenets of regional business cycle theory. The most notable example is the durable goods sectors. When sectoral final demands are expanding, the consumption of durable goods tends to increase, whereas when sectoral final demands are contracting, the consumption of durable goods tends to decrease. According to these examples, the covariance between fluctuations in household consumption of durable goods and sectoral final demands can destabilize the regional economy. In contrast, the consumption of non-durable consumption goods tends to be fairly constant over time. That is C and $F_D$ tend to be uncorrelated (i.e., independent) for non-durable goods.

The 'Permanent Income Hypothesis' attempts to explain the relative stability of C. According to this hypothesis consumers plan their consumption based on a life-time stream of expected income. Thus, short-run fluctuations in income have a limited effect on consumption patterns [Peterson (1988), p.178].

The impact of short-run economic fluctuations on consumption patterns will depend, to a large degree, on how firms adjust, and how government responds to business cycles. For example, firms may adjust through pay cuts, layoffs, or reduced hours, and government may provide assistance benefits to economically distressed workers. These labor-related factors are discussed in the next section.

### 3.4.3.4 Covariance Between Labor Force Characteristics and Sectoral Final Demands - $COV[Q,F_D]$, $COV[W,F_D]$, $COV[S,F_D]$

There tends to be some correlation between the fluctuations in sectoral final demands and labor force characteristics. $COV[Q,F_D]$ measures the covariance between occupation-household relations and sectoral final demands. When sectoral final demands are expanding, labor force participation rates tend to increase. There will also be induced impacts from the increased labor participation rates. Hence, Q is positively correlated with $F_D$, and $COV[Q,F_D]$ can destabilize the regional economy.

$COV[W,F_D]$ measures the covariance between income-occupation relations and sectoral final demands. When sectoral final demands are expanding, income from wages and profits tend to increase. There will also be induced impacts from the increased income. It would seem that $COV[W,F_D]$ might potentially destabilize the regional economy. However, $COV[Q,F_D]$

is constrained by market and institutional forces. If increasing sectoral final demands lead to increases in wages and profits, then regional competitiveness may be negatively affected. In contrast, if sectoral final demands are decreasing, residents might accept lower wages and profits, which could, in turn, improve regional competitiveness. Institutional factors, which include unions, wage agreements, etc., are often characterized by their role as stabilizers of regional economic activity.

These institutional forces can vary from region to region. For example, the South is known for its anti-union bias, which allows firms greater flexibility in adjusting to economic fluctuations. Although this flexibility in labor retention, wage rates, and hours may lead to greater profits or competitiveness for firms, it might also lead to greater economic instability for individuals and from a region-wide perspective.

$COV[S,F_D]$ measures the covariance between occupation-output relations and sectoral final demands. When sectoral final demands are expanding, producers facing capacity constraints might use different labor and capital combinations, depending on their relative scarcity. Technical factors that characterize various types of labor, and labor:capital ratios constrain the extent of substitution. Also, institutional forces can constrain the degree of substitution. Hence, $COV[S,F_D]$ will probably exert only a small stabilizing impact.

As can be deduced from these observations, there will be a correlation between fluctuations in sectoral final demands and labor force characteristics, however, the direction of the impacts are somewhat ambiguous and the magnitude of the impacts tend to be constrained by both market and institutional forces, and by technical factors.

#### 3.4.3.5 Covariance Between Exogenous Income and Sectoral Final Demands - $COV[F_C,F_D]$

By definition, fluctuations in exogenous income should be independent or, at most, weakly correlated with fluctuations in sectoral final demands. However, in practice, some transfer payments will be negatively correlated with sectoral final demands (e.g., unemployment benefits, and other public assistance), and some rental payments and dividend payments from extra-regional assets, firms, and businesses might be positively correlated with sectoral final demands due to business cycles. Hence, the direction and magnitude of $COV[F_C,F_D]$ is ambiguous, although for some types of exogenous income, a specific relationship may exist.

#### 3.4.3.6 Variance of Sectoral Final Demands - $COV[F_D,F_D]=VAR[F_D]$

According to economic base theory and business cycle theory, the variance of sectoral final demands, $VAR[F_D]$, is the major source of variability in sectoral output, and $COV[p^A,F_D]$, $COV[p^C,F_D]$, $COV[C,F_D]$, $COV[Q,F_D]$, $COV[W,F_D]$, $COV[S,F_D]$, $COV[A,F_D]$, $COV[F_C,F_D]$ can either stabilize or destabilize the regional economy. As was observed in the brief discussion above, the actual direction and magnitude of these covariances are sector- and region-specific.

Numerous factors contribute to the fluctuations in the sectoral final demands. As pointed out in Section 3.3.7, sectoral final demands are gross revenues received by producers, and they can be decomposed into price and quantity components. Hence, the fluctuations in the ith sector's final demands, and the covariances with the other j sectors are caused by changes in both demand and supply factors. According to regional business cycle theory, spatial-hierarchal development theories, and economic development theory, the elasticities and cross-elasticities of demand and supply will have an important impact on the overall variance of sectoral final demands. In the operational model presented in Chapter 4, it is assumed that the stability of regional income and employment are a function of the variance of exogenous final demands.

### 3.5 CONCLUSION TO THIS CHAPTER

As mentioned previously, equations (3.84) and (3.85), which can be considered a probabilistic input-output version of the standard input-output model, are used as the basis for the operational model presented in Chapter 4. Although the growth or stability of sectoral output can come from any of the sources detailed in the growth and stability decompositions (as well as from other sources), the operational model focuses attention on the relationship between the growth and stability of exogenous sectoral final demands and the endogenous growth, stability, and distribution of regional income and employment.

The probabilistic input-output version of the standard input-output model is a projection model that assumes linear production and consumption functions, a fixed sectoral output multiplier, fixed prices, no resource constraints, and no substitution among inputs. The detailed growth and stability decompositions in this chapter indicate that in some circumstances these assumptions may be unrealistic. In fact, numerous nonlinear relationships were described. By simultaneously presenting the conceptual framework and the simplifying assumptions used for the operational model, the differences between a 'full' and 'partial' information model were made transparent. As such, (i) planners can use the conceptual framework as a guide for adjusting the operational model for some of the 'missing' information, (ii) and researchers can explore the empirical importance of the missing information, and formulate models that fill the most important gaps.

Dynamic input-output models and computable general equilibrium models are explicit attempts to incorporate some of the information missing from the standard input-output model. It may be possible to use the conceptual framework presented in this chapter as a basis for combining standard input-output, dynamic input-output, and computable general equilibrium models into an operational framework that minimizes the amount of missing information, without resorting to the high cost the more detailed models.

# CHAPTER 4 OPERATIONAL MODEL

From Sir Eric Roll's A History of Economic Thought:

"David Ricardo is without a doubt the greatest representative of political economy. He carried the work begun by Smith to the farthest point possible without choosing the road which led out of the contradiction inherent in it. Perhaps for that reason recognition of his importance has sometimes been withheld and has often been grudging. Jevons was convinced that Ricardo had given economic enquiry a wrong twist; the American economist, Carey, regarded the 'Principles' as the source of inspiration of agitators and disruptors of society; and a modern writer, who gives abundant praise to Smith, has gone so far as to call Ricardo's literary work 'the production of an unliterary Jewish stockbroker' distinguished by a certain inherited 'Jewish subtlery' [Roll (1973), p.173-174]."

"[Marx] argues, the identity of production and consumption exists only if we ignore the social relationship which mediates between them. This mediation is distribution. Superficially, distribution means distribution of products. But before it can be that, it has to be 'first a distribution of the means of production and secondly (which is only a further quality of the same relationship), a distribution of the members of society among the different branches of production.' Production must, therefore, presuppose such a distribution. And distribution in the conventional sense is determined by distribution as a social element in the process of production. Ricardo, according to Marx, was getting near the truth when he made distribution, rather than production, the subject of political economy. He erred in thinking that the laws of production were natural and not historical [Roll (1973), p.259]."

## 4.0 INTRODUCTION TO THIS CHAPTER

Chapter 4 presents an operational model that can be used to apply the conceptual and analytical framework presented in Chapter 3. The objective of the operational model is to provide a mechanism that can be used to quantify the relationship between changing economic structure and performance.

## 4.1 PERSPECTIVE OF THE MODEL

This chapter presents a model of a regional economy from the perspective of a planner who is evaluating the relationship between economic structure in a base period, and anticipated economic performance. By making assumptions about a region's initial economic structure, and about the expected growth and stability of sectoral final demands, the planner can use the model to calculate measures of anticipated economic performance. Hence, the model can be used to evaluate economic performance *ex ante*. Anticipated economic performance is measured as the expected growth and stability of regional income and employment, and its distribution among different occupation groups. The measures of anticipated economic performance can be used to compare, and/or to rank alternative strategies in terms of their respective contributions to a region's social welfare.

The following analytical framework has several features that differentiate it from previous analyses of regional economic diversification. First, a region's economic structure and performance are measured using an extended input-output model, which is based on a system of social accounts. This provides a theoretical basis for assumptions about the relationship between economic structure and economic performance. Second, the analytical framework distinguishes between what a region does and what it makes. Previous studies have analyzed economic diversity in terms of sectors--what a region produces. In this model, the growth and stability of final demand are measured and aggregated by sector. However, the growth and stability of regional income and employment are measured and aggregated by occupation groups --what people in a region do. The model thus distinguishes between the sectoral diversity of final demands, and the occupational diversity of the labor force. The third feature that differentiates this model is that, by design, the model can be used to analyze distributional impacts, since the occupation groups can be sorted by earnings per individual. Fourth, both income and employment impacts are included when evaluating a region's social welfare. Hence, the approach explicitly addresses potential growth-stability tradeoffs, and distributional impacts.

## 4.2 MEASURING A REGION'S SOCIAL WELFARE

According to the approach taken in this study, the 'ideal' balance of economic structure is determined by examining the relative economic performance of various feasible structures. These elements of performance determine social welfare. Economic diversification or diversity is only a goal inasmuch as it facilitates the enhancement of social welfare goals.

An individual's real income, received as returns on labor and capital or as transfer payments, is a measure of his or her purchasing power. Because of this, real income is a measure of an individual's utility. However, real income is not a complete measure of an individual's total utility since it fails to reflect the value of non-market goods and services. An individual's utility will also include other social, political, and environmental goods and services (among other things) that are characterized by imperfect or non-existent markets. Furthermore, it is often claimed that an individual derives utility both from the level of different economic, social, political, and environmental goods and services at any given point in time, and from the growth and stability of the respective levels over time.

Without specifying a particular functional form or specifying a common metric for the respective indices of an individual's utility, the social welfare of a region with m individuals (or m groups of homogeneous individuals) can be depicted as:

(4.1)

$$WELL = f(Y, GRO(Y), STAB(Y), Z_i, GRO(Z_i), STAB(Z_i)) ,$$

where:

WELL = an aggregate region-wide measure of social welfare,

Y = mx1 vector of the level of income,

GRO(Y) = mx1 vector of the growth of income,

STAB(Y) = mx1 vector of the stability of income,

$Z_i$ = mx1 vectors of the level of i=1,...,∞ other economic, social, political, environmental, etc. components of utility,

GRO($Z_i$) = mx1 vectors of the growth of i=1,...,∞ other economic, social, political, environmental, etc. components of utility, and

STAB($Z_i$) = mx1 vectors of the stability of i=1,...,∞ other economic, social, political, environmental, etc. components of utility.

One $Z_i$ component of an individual's utility is his or her employment status. Most people would experience a change in utility if their employment status changed, even if their level of income remained constant (e.g., through transfer payments). An individual can derive utility from his or her employment status, independent of the level of income. Hence, an individual's level of income, and employment status can be considered separate determinants of utility.

In addition, it is important to consider both income and employment impacts in regional economic impact analyses, because there is not necessarily a perfect correspondence between income and employment impacts from an individual's perspective, or from a region-wide perspective [Siegel and Johnson (1991)].

The model includes both income and employment as separate components of utility. Other economic, social, political, environmental, etc. components of utility are not considered. However, the model can be extended to include other components of utility. This was pointed out in Section 3.1 where it was shown how response coefficients for pollution could be used to measure environmental impacts.

For the comparison and ranking of alternative states, it is assumed that social welfare depends only on the utilities of individuals residing in the region. Without specifying a formal social welfare function, it is assumed that a region's social welfare is based on 'individualism', the 'Pareto principle', and the 'property of strong separability'. According to individualism, it is assumed that the social ordering should be based on individual orderings of alternative social states (i.e., based on individual preferences), and each individual is the best judge of his or her own preferences. In its strongest form, the Pareto principle asserts that if social state A is ranked higher than social state B for one individual, and all other individuals rank A at least as high as B, then A should be ranked higher than B in the social ordering. According to the property of strong separability, the change in utility of any individual is independent of the change in utility of other individuals (i.e., there are no interpersonal comparisons of utility) [Boadway and Bruce (1984), Chapter 1].

There is not a complete ordering of social states (and hence, there is an incomplete ordering of alternative development strategies) when a region's social welfare is based only on individualism, the Pareto principle, and the property of strong separability [Boadway and Bruce (1984), p.138]. In particular, two states, A and B, can not be compared if A is preferred by some individuals and B is preferred by other individuals. From a regional planning perspective, the inconclusive ranking of alternative strategies would be a drawback if the purpose was to find the optimal strategy. However, in practice, it is the planner's role to provide objective information about the impacts of alternative strategies, and for the political process to rank them. That is, the planner provides the basis for comparing alternative development strategies, whereas the political process compares the alternatives and ranks them.

For the operational model presented in this chapter, it is assumed that income and employment status are the central economic components of individual utility. Specifically, the focus is the growth and stability of an individual's income and employment, where individuals are aggregated by occupation group. This assumes that, given the level of income and employment at a point in time, an individual's utility depends on the future prospects of his or her income and employment status.

Hence, without specifying a particular functional form, the social welfare of a region with j = 1,..., m individuals is assumed to be:

(4.2)

$$WELL = U\ (U^j(GRO(Y_j), STAB(Y_j), GRO(L_j), STAB(L_j)))\ ,$$

where:

U(.) is a discontinuous aggregator function,

$U^j$ is the utility of the jth individual, and

L is employment status (e.g., number of hours worked).

Thus, a region's social welfare is assumed to be a <u>composite</u> (i.e., discontinuous aggregate) of the utilities of individuals, not a <u>summation</u> of utilities. U(.) is a general function that obeys the properties of individualism, the strong Pareto principle, and the property of strong separability.

It is assumed that an individual's utility is positively (negatively) affected by positive (negative) changes in anticipated income and employment status, and by increases (decreases) in the inherent stability of income and employment status.

The anticipated growth and stability of income and employment are measured based on the expected growth and stability of different occupation groups. That is, each individual is assumed to be a member of a specific occupation group, and it is assumed that each individual's prospect is based on the anticipated performance of his or her respective occupation group.

### 4.3 CHOOSING AN AGGREGATION SCHEME

The selection of an aggregation scheme has important implications for: (i) the analysis of distributional impacts, and the ranking of alternative strategies, and (ii) the use of the operational model for planning purposes.

Regional analyses are usually carried out with individuals and firms grouped together according to some aggregation scheme. As was pointed out in Section 2.2, firms are usually aggregated by sector. Typically, individuals are aggregated by sectors (for production-oriented analysis) or households (for consumption-oriented analysis). In some cases a region-wide perspective is taken, whereby all firms and individuals in a region are aggregated into single units of analysis.

Since there is an implicit assumption that individuals in a certain group are similar, the aggregation scheme will have a critical bearing on the analysis of distributional impacts, and the ranking of alternative strategies. The aggregation scheme will dictate the basis for analyses of distributional impacts and, to a large degree, dictate whether an analysis of distributional impacts is even undertaken.

### 4.3.1 The Aggregation Scheme and Distributional Impacts

Previous studies on economic diversification used region-wide measures of economic diversity, and region-wide measures of economic stability. This was discussed in Chapter 2. Region-wide measures were constructed, in part, because they were used to test hypothesized relationships between economic diversity and stability. Although the measures of diversity and stability were constructed using a sectoral aggregation scheme (e.g., the sectoral distribution of income or employment), the comparison and ranking of alternative strategies used a region-wide aggregation scheme, which ignored distributional impacts (or alternatively, assumed that distributional impacts are not relevant for the analysis).

A planner using these measures for region-specific analysis would generate region-wide measures of economic structure and performance that ignore distributional impacts. In turn, the results presented by the planner to the political process for comparison and ranking, would lack an analysis of individual winners and losers. In this case, the implied decision rule for comparing and ranking alternative social states is the 'weak Pareto rule', whereby social state A is ranked higher than social state B, if, in theory, winners can compensate losers. So, the rich may get richer, and the poor may get poorer, and A may still be preferred to B. This may be the social ordering criteria used by the political process in some regions, but it is not a universally accepted decision rule.

Gilchrist and St. Louis (1991) present an operational model based on a portfolio theoretic approach to economic diversification. Their operational model is based on a structural model of a regional economy that bears some similarities to the model presented in this chapter. Their model measures economic performance in terms of the growth and stability of sectoral employment. They propose a social welfare criterion for ranking alternative strategies that is similar to that presented in Section 4.2. That is, when comparing a base period's economic performance to a terminal period's economic performance, an unambiguous improvement in social welfare occurs only if all sectors (i.e., in this chapter, occupation group) experience improved growth and greater stability (also, improved growth and no change in stability, or vice versa). An unambiguous deterioration in social welfare occurs only if all sectors are characterized by less growth and by greater instability. For any other outcomes there are ambiguous results (i.e., a mix of winners and losers), and the political process must rank them.

### 4.3.2 The Aggregation Scheme and Planning

Past studies that used the portfolio theoretic approach to economic diversification have implicitly assumed that labor is homogeneous and mobile between sectors, or that there is an unconstrained labor supply. When using the portfolio theoretic approach, it is assumed that sectors with negatively correlated fluctuations in employment levels will stabilize overall regional employment, because homogeneous labor will move between sectors, or because labor is not scarce.

Gilchrist and St. Louis (1991) explicitly assume that labor is homogeneous and mobile between sectors. In their simulation of alternative strategies, they reallocate the regional labor force among sectors. In one application of their model they reallocate labor from the agricultural sector to other sectors. Assuming the homogeneity and mobility of labor may not be a realistic assumption.

In reality, there can be a great deal of heterogeneity in the occupational mix of a sector (consider, for example, the heterogeneity of occupations in a university). The heterogeneity of occupations within a sector, and between sectors have important implications for intersectoral movement of labor, and the income and employment impacts of alternative development strategies.

To deal with the heterogeneity of occupations within a given sector and between sectors, the following operational model aggregates individuals according to occupation groups. This is a more 'people-oriented' aggregation scheme than sectors since, in practice, individuals are often identified on the basis of their occupation. That is, results organized by occupation group (e.g., the growth and stability of regional income and employment) can better facilitate the identification of winners and losers from alternative development strategies. This information can, in turn, be used in the comparison and ranking of alternatives.

Aggregating by occupation can also provide important information for planning purposes. Occupational diversity of the labor force is potentially a more important determinant of the growth and stability of regional income and employment than sectoral diversity of the labor force. For regions contemplating industrial targeting and recruitment to achieve economic diversification, there are practical advantages to the occupational diversity approach over the sectoral diversity approach of the labor force [Smith (1990); Thompson and Thompson (1987)]. Regions must assess their key resources and determine how they can be most efficiently allocated. In many cases a region's key resource is its human resource base, the occupation mix of the labor force [John et al. (1988), p.2].

Planners can match anticipated labor force demands with the existing regional labor force, looking at both surpluses and shortfalls of different occupation groups. Some regional policies can influence the occupational mix of the labor force by education, training, and by developing manpower, or through policies (e.g., taxes, services, education) that attract in-migrants with the desired occupations [Smith (1990), p.13; Thompson and Thompson (1987), p.547]. This subject was addressed in Section 3.3.5.

For planning purposes, the sectoral diversity of exogenous final demands--the sectoral mix of what a region makes (and exports)--is critical. The pivotal role of the growth and stability of a region's exogenous final demands was emphasized in Chapter 3. The operational model presented in this chapter is driven by the growth and stability of a region's exogenous final demands.

Industrial targeting and recruiting should be based on both: (i) an evaluation of what a region makes (e.g., forecasts of exogenous final demands by sector), and (ii) an evaluation of what the region does (e.g., forecasts of labor supply and demand based on occupations).

### 4.3.3 The Aggregation Scheme, Distribution Impacts, and Planning

Depending on the purpose of the analysis, other aggregation schemes can be used. For analyses that are specifically concerned with distributional equity, individuals are usually aggregated according to households. In extended input-output models that use social accounts, individuals are usually aggregated by households for the analysis of both economic structure and performance, using coefficients that arrange individuals grouped by occupations into household groups sorted by income class [Bernat and Johnson (1991)]. In contrast, Painton (1991) aggregates individuals according to households for the analysis of economic structure, and according to occupation groups for the analysis of economic performance.

In the following model, consumption patterns are modeled using coefficients that arrange individuals aggregated by occupation groups into household groups based on income classes. This is the Q in

$R = (I - p^A A - p^C CQWS)^{-1}$) from equation 3.10. However, for the analysis of the growth, stability, and distribution of regional income and employment, individuals are aggregated into occupation groups based on income class.

Measures of distributional equity must be based on some judgments about what constitutes an equitable distribution of income among households. These judgments can lead to either normative or positive measures of distributional equity [Rose et al. (1988)]. The following operational model does not measure distributional equity impacts; it measures distributional impacts. However, the measures of distributional impacts could be used to calculate distributional equity impacts if coupled with an equity criterion. Such an extension of the model is discussed in Section 4.8.

## 4.4 CHOOSING AN ACCOUNTING STANCE

The measure of a region's social welfare also depends on the accounting stance. Once an aggregation scheme is specified, the accounting stance can be chosen. The accounting stance determines whose utility counts in a region's social welfare. There is no theoretically correct way to specify a region's accounting stance. Instead, each region must determine its own. The appropriate accounting stance will vary from region to region, and will also depend on the purposes of the analysis.

The selection of an accounting stance is especially important for regions experiencing population change through either in- or out-migration. For example, for rural regions:

> "a successful diversification strategy may drastically change the face of the community. Broad expansion of the economic base is likely to attract in-migrants who may take many of the jobs generated by the new economic activities. Local residents may still benefit from jobs generated by the new activities, but these are more likely to be lower-paying opportunities [Belzer and Kroll (1986), p.21]."

There is a longstanding debate on whether the comparison and ranking of alternative strategies should count only the impacts on existing residents or also include the impacts on in-migrants. Hamilton et al. (1991) review several studies that debate the issue of the 'theoretically correct' accounting stance, and then claim that only existing residents should be included in a region's accounting stance.

However, the issue of residency is not so straightforward.

> "A region is not, except at an instant in time, a definite group of people--it is an area populated by a changing group of people... [The] continual turnover of a region's population complicates the question of policy goals. What is to be maximized over, say, the next ten years? The welfare of the present inhabitants of the region, regardless of where they may be in ten years time? The welfare of those who will be living in the region in ten years hence, regardless of where they are now? Should it be counted as a regional gain if some people move in whose incomes are above the regional average, so that the average rises with their advent? If so, should one of the aims of regional policy be the out-migration of its poorer inhabitants [Hoover and Giarratani (1984), p.357]?"

When using the operational model to simulate alternative development strategies, it is possible to sub-divide each occupation group into: (i) residents employed in the base period, (ii) residents unemployed in the base period, (iii) in-migrants, (iv) out-commuters, and (v) in-commuters. Then the region's political process can chose an accounting stance based on the inclusion or exclusion of various sub-groups, as it deems appropriate.

From an analytical perspective, it is also important to distinguish between the different sub-groups, because the impacts on regional income and employment will depend on which sub-groups are affected by a specific strategy [Blackwell (1978)]. For example, a jobs-oriented policy might have a relatively high employment impact and relatively low income impact, if previously unemployed residents forfeit transfer payments to accept low-paying jobs.

Previous studies of regional economic diversification have not explicitly specified an accounting stance. Therefore, they have not considered the impacts of population changes on regional income or employment. Gruben and Phillips (1986) show that population changes can have an important impact on the growth and stability of regional income and employment (and unemployment).

## 4.5 MODELLING THE RELATIONSHIP BETWEEN THE GROWTH AND STABILITY OF EXOGENOUS FINAL DEMANDS, AND THE ENDOGENOUS GROWTH, STABILITY, AND DISTRIBUTION OF REGIONAL INCOME AND EMPLOYMENT

The operational model measures the growth, stability, and distribution of regional income and employment as a function of the growth and stability of exogenous final demands.

### 4.5.1 Calibrating the Base-Period Economic Structure and Performance

Based on different assumptions about a region's base-period economic structure, and different assumptions about the anticipated growth and stability of sectoral final demands, simulations of alternative development strategies can be carried out.

Recalling equations (3.9) to (3.11) from Section 3.1, a region's economic structure, RF, and performance, X, can be depicted by:

(4.3)

$$X = RF \ ,$$

where the regional output multiplier is:

(4.4)

$$R = (I - p^A A - p^C CQWS)^{-1} \ ,$$

and the sectoral final demands are:

(4.5)

$$F = p^C CF_C + F_D \ .$$

Recalling equations (3.84) and (3.85) from Section 3.4.3, for a deterministic sectoral output multiplier and stochastic sectoral final demands, a probabilistic version of the standard input-output model can be written as:

(4.6)

$$E[X] = R \ E[F] \ ,$$

and

(4.7)

$$VAR[X] = R \ VAR[F] \ R^T,$$

where E[X] is the expected growth of sectoral output, and VAR[X] is the stability of sectoral output.

Recalling equations (3.14) and (3.15) from Section 3.1, regional income and employment by occupation group can be calculated as:

(4.8)

$$Y = WSX = WSRF \,,$$

and

(4.9)

$$L = SX = SRF \,,$$

where Y and L are sx1 vectors of the level of income and employment, by occupation group.

Equations (4.3) to (4.9) serve as the foundation of the operational model. The operational model is a projection model driven by the growth and stability of sectoral final demands because it assumes that the structural factors ($p^A$, A, $p^C$, C, Q, W, and S) are fixed for the period of analysis (see Sections 3.1 and 3.4.1). To model changes in structural factors, it is necessary to adjust their base period values (see Section 3.4.3). Hence, to simulate alternative development strategies, changes in structural factors must be modelled a priori. That is, the base-period model must be calibrated to reflect the $\Delta p^A$, $\Delta A$, $\Delta p^C$, $\Delta C$, $\Delta Q$, $\Delta W$, and $\Delta S$ described in Sections 3.3.1 to 3.3.5.

The first step in using the model is to specify the base-period economic structure and performance, $X_t = R_t F_t$. A region's existing economic structure and performance will be a major determinant of the impact of alternative development strategies. The second step is scenario development. The decomposition of growth of sectoral output presented in Sections 3.3.1 to 3.3.7 should be used to identify alternative development strategies, and the corresponding anticipated changes in structural factors and/or exogenous final demands. Any anticipated changes in structural factors must be incorporated into the base-period model, and the projection model will then be based on anticipated changes in exogenous final demands. The third step is to follow the steps outlined in Sections 4.5.2 to 4.5.5.

### 4.5.2 The Growth of Exogenous Final Demands by Sector

A widely used method of measuring the expected level of a variable is to use its trend from time-series data. The choice of a particular statistical model (i.e., functional form) to calculate the trend is critical for both the measure of anticipated growth, and the measure of stability (since stability is measured as deviations from the trend). Whatever statistical model is used to calculate the trend, it is possible to denote the expected level of exogenous final demand by sector as $E[F_t]$ in time period t (the base-period), and as $E[F_{t+1}]$ in time period t+1 (the terminal period). If the base-period levels are known, then $E[F_t] = F_t$.

The anticipated growth in exogenous final demands by sector can be calculated as:

(4.10)

$$E[\Delta F_i] = E[F_{i\ t+1}] - E[F_{it}] \ ,$$

where $E[\Delta F_i]$ is a stochastic variable written in difference equation form, like $E[\Delta X]$ in equation (3.50) in Section 3.4.1. $E[\Delta F_i]$ can be positive, negative, or zero.

The anticipated region-wide growth in exogenous final demands can be calculated as:

(4.11)

$$\sum_{i=1}^{n} E[\Delta F_i] = \sum_{i=1}^{n} E[F_{i\ t+1}] - \sum_{i=1}^{n} E[F_{it}] \ .$$

#### 4.5.3 The Stability of Exogenous Final Demands by Sector

The variance of exogenous final demands by sector, the matrix $VAR[F_i] \equiv VAR\text{-}COV[F_i, F_j]$, is used as a measure of stability. The variances and covariances of a region's exogenous final demands by sector are measured using normalized deviations from the trend, and the trend for the ith sector's exogenous final demands in period t is assumed to be $E[F_{it}]$.

The normalized variances and covariances can be calculated as:

(4.12)

$$VAR\text{-}COV[F_i, F_j] = \frac{1}{T_*}\sum_{t=1}^{T_*} \left(\frac{F_{it} - E[F_{it}]}{E[F_{it}]}\right) \left(\frac{F_{jt} - E[F_{jt}]}{E[F_{jt}]}\right) .$$

The diagonal elements of the variance-covariance matrix $VAR\text{-}COV[F_i, F_j]$ are the variances of the ith sector's exogenous final demand, $VAR[F_i]$, and the off-diagonal elements are the covariances between different sectors' exogenous final demands, $COV[F_i, F_j]$.

Each sector's contribution to the stability of exogenous final demands can be decomposed into the following weighted variance and covariance terms:

(4.13)

$$VAR\text{-}COV[F_i, F_j] = \alpha_i^2 VAR[F_i] + \sum_{j=1,\ j\neq i}^{n} \alpha_i \alpha_j COV[F_i, F_j] ,$$

where the weights are sectoral shares of exogenous final demand, calculated as:

(4.14)

$$\alpha_i = E[F_{i\ t+1}] \ / \sum_{i}^{n} E[F_{i\ t+1}] \ .$$

Each sector's contribution to the region-wide stability of exogenous final demands is a function of: (i) its own stability, (ii) the interaction between its own stability and the stability of other sectors, (iii) its share of the region's exogenous final demands, and (iv) the shares of other sectors.

The region-wide measure of the stability of a region's exogenous final demands is the weighted sum of all variance and covariance terms in equation (4.13):

(4.15)

$$VAR\text{-}F = \sum_{i=1}^{n} \alpha_i^2 \ VAR[F_i] \ + \sum_{i=1}^{n} \ \sum_{j=1, j\neq i}^{n} \alpha_i \alpha_j \ COV[F_i, F_j] \ .$$

Recalling equation (2.11) in Section 2.6.2.2, the measure of region-wide stability in equation (4.15) can be called the 'portfolio variance' of a region's exogenous final demands.

The measure of the stability of exogenous final demands explicitly accounts for intersectoral relationships because both variance and covariance terms are included. Covariances of exogenous final demands are fundamental factors for the formulation of development strategies (i.e., diversification policies) that change the mix of exogenous final demands. If exogenous final demands from sectors i and j are negatively correlated, this covariance lowers the aggregate variance of a region's exogenous final demands (the relationship between covariances and correlation coefficients was shown in equation (2.13) in Section

2.6.2.2). Even if there are no negative correlations, as long as the correlations between a region's exogenous final demands are not perfectly positive, then benefits of diversification can be realized. That is, the addition of new sectors can reduce the aggregate region-wide variance of exogenous final demands because $\alpha_i^2$ gets smaller as n increases to an asymptotic limit [Schoening and Sweeney (1991), p.2]. This is one reason that past studies have advocated diversification through increasing the diversity (i.e., variety) of economic activity. In the context of a stabilization policy, this may achieve the goal of stability, however, potential growth-stability tradeoffs and the distribution impacts are ignored.

Using the weighted variances and covariances as a measure of stability, the impacts of alternative sectoral mixes of exogenous final demands can be compared. By making various assumptions about the growth of each sector's exogenous final demands, and examining correlation coefficients, the aggregate variance of exogenous final demands can be lowered. Evaluating alternative strategies based on different assumptions about the anticipated growth of exogenous final demands by sector will require a recalculation of the sectoral weights in equation (4.14). As sectoral shares change, and the weights associated with sectoral variances and covariances change, the aggregate regional variance (i.e., stability) of exogenous final demands, as measured in equation (4.15), above, will change.

When using a portfolio-type analysis for an operational model, it should be recalled that there are important statistical issues to be addressed. In addition to the changing sectoral shares, which are easily measured, the direction and magnitude of individual correlation coefficients may be changing over time [Ali et al. (1991); Steib and Rittenoure (1989)]. That is, the underlying structure of the statistical model used to estimate variances and covariances may be changing. For example, the expansion of existing sectoral activity, or additions of new sectoral activities, may lead to changes in the pattern of intersectoral stability. As mentioned in Chapter 3, there are numerous important statistical issues to be addressed when applying the model, however, they are outside the scope of this study.

### 4.5.4 The Growth in a Region's Income and Employment by Occupation Group

The anticipated growth in regional income and employment are defined as the expected changes in a region's income and employment by occupation group, which are a function of expected changes in sectoral levels of exogenous final demands. As mentioned in Section 4.2, it is assumed that each individual is a member of a specific occupation group, and measures his or her own prospects based on the anticipated performance (growth and stability) of his or her occupation group.

The anticipated growth in regional income by occupational group is measured as:

(4.16)

$$E[\Delta Y_q] = E[Y_{q\,t+1}] - E[Y_{qt}] \ ,$$

which is derived from:

(4.17)

$$E[Y_{t+1}] - E[Y_t] = (WS)(R)(E[F_{t+1}] - E[F_t]) \ ,$$

where $E[Y_{qt}]$ and $E[Y_{q\,t+1}]$ are the expected levels of income by occupation group (q=1,...,s) in time periods t and t+1. If the base-period levels of income are known, then $E[Y_{qt}] = Y_{qt}$.

The anticipated growth in regional employment by occupation group is measured as:

(4.18)

$$E[\Delta L_q] = E[L_{q\,t+1}] - E[L_{qt}] \ ,$$

which is derived from:

(4.19)

$$E[L_{t+1}] - E[L_t] = (S)(R)(E[F_{t+1}] - E[F_t]) \ ,$$

where $E[L_{qt}]$ and $E[L_{q\,t+1}]$ are the anticipated levels of employment by occupation group (q=1,...,s) in time periods t and t+1. If the base-period levels of employment are known, then $E[L_{qt}] = L_{qt}$.

Equations (4.16) and (4.18) quantify the relationship between the anticipated change in exogenous final demands by sector, and the anticipated change in endogenous regional income and employment by occupational group.

Based on equations (4.16) and (4.18) region-wide measures of anticipated changes in regional income and employment can be calculated as:

(4.20)

$$\sum_{q=1}^{s} E[\Delta Y_q] = \sum_{q=1}^{s} E[Y_{q\,t+1}] - \sum_{q=1}^{s} E[Y_{qt}] \ ,$$

and

(4.21)

$$\sum_{q=1}^{s} E[\Delta L_q] = \sum_{q=1}^{s} E[L_{q\ t+1}] - \sum_{q=1}^{s} E[L_{qt}] \ .$$

### 4.5.5 The Stability of a Region's Income and Employment by Occupation Group

Using the matrix of normalized variances and covariances of exogenous final demands presented in equation (4.12) and the sectoral weights in equation (4.14), the variance-covariance matrix of regional income by occupation group can be calculated as:

(4.22)

$$VAR\text{-}COV[Y_q, Y_g] = (WS)\,(R)\,\alpha\, VAR\text{-}COV[F_i, F_j]\,\alpha^T\,(R^T)\,(WS)^T \ ,$$

where $\alpha$ is the diagonal matrix of sectoral weights defined in equation (4.14). This measure is an extension of the weighted variance of exogenous final demands that was presented in equations (3.71) and (3.83) in Section 3.4.2, and described as 'D1' in Section 3.4.3.

For s occupations, the diagonal elements of the sxs variance-covariance matrix, VAR-COV[$Y_q$,$Y_s$], are the variances of each occupation's income, VAR[$Y_q$], that is, the stability of regional income by occupation group. The off-diagonal elements are the covariances between different occupation's income. The variance and covariances of exogenous final demands by sector are weighted by the squares of: (i) the sectoral shares of exogenous final demands, $\alpha$, (ii) the sectoral output multiplier, R, and (iii) the WS matrix which relates value-added by occupation to output by sector.

Hence, the mix of exogenous final demands ($\alpha F$), the relative degree of intersectoral linkages and leakages ($p^A A$ and $p^C CQWS$), and the proportion of value-added retained in the region (W), and its distribution by occupation group (WS), will determine the extent that the stability (or instability) of sectoral final demands are transmitted through the regional economy.

A similar measure is mentioned, as an aside, by Berck et al. [(1989), p.22]:

> "This formula shows that the variance in household incomes depends upon the covariances of the final demands... This way of thinking about the problem is akin to portfolio theory, although previous practitioners do not recognize the role of the SAM multiplier. We shall not follow through this approach here."

They continue:

> "This has very interesting and ironic implications as far as community development and local development strategy is concerned. For some rural communities in decline have been told to look for import substitution and/or low leakage activities for economic development purposes... However, this ... does not capture the full consequences of diversification. An import substitution policy necessarily has lower leakages to the rest of the economy. Lower leakages mean higher multipliers, and stability varies as the square of the multiplier [ibid, p.23]."

Berck et al. (1989) are referring to the stability impacts that result from $\Delta p^A A$ or $\Delta p^C CQWS$ (see Sections 3.4.1 and 3.4.3).

Similarly, using the matrix of normalized variances and covariances of exogenous final demands presented in equation (4.13), the variance-covariance matrix of regional employment by occupation group is measured as:

(4.23)

$$VAR\text{-}COV[L_q, L_g] = (S)(R)\alpha VAR\text{-}COV[F_i, F_j]\alpha^T (R^T)(S)^T .$$

For s occupations, the diagonal elements of the sxs variance-covariance matrix, VAR-COV[$L_q$,$L_k$], are the variances of each occupation's employment, VAR[$L_q$], that is, the stability of regional employment by occupation group. The off-diagonal elements are the covariances between different occupation's employment. The variance and covariances of exogenous final demands by sector are weighted by the squares of: (i) the sectoral shares of exogenous final demands, $\alpha$, (ii) the sectoral output multiplier, R, and (iii) the S matrix which relates occupations to output by sector.

Equations (4.22) and (4.23) quantify the relationship between the stability in exogenous final demands by sector, and the stability of endogenous regional income and employment by occupational group. It is also possible to quantify the relationship between the stability in exogenous final demands by sector, and the region-wide stability of regional income and employment.

A region-wide measure of the stability of a region's income is the weighted sum of all the variances and covariances in equation (4.22):

(4.24)

$$VAR\text{-}Y = \sum_{q=1}^{s} \gamma_q^2 \, VAR[Y_q] + \sum_{q=1}^{s} \sum_{g=1,\, g\neq q}^{s} \gamma_q \gamma_g \, COV[Y_q, Y_g] \ ,$$

where the weights, income shares by occupation group, are calculated as:

(4.25)

$$\gamma_q = E[Y_{q\,t+1}] \ / \ \sum_{q=1}^{s} E[Y_{q\,t+1}] \ .$$

A region-wide measure of the stability of a region's employment is the weighted sum of all the variances and covariances in equation (4.23):

(4.26)

$$VAR\text{-}L = \sum_{q=1}^{s} \kappa_q^2 \; VAR[L_q] \; + \sum_{q=1}^{s} \; \sum_{g=1,\, g\neq q}^{s} \kappa_q \kappa_g \; COV[L_q, L_g] \;\; ,$$

where the weights, employment shares by occupation group, are calculated as:

(4.27)

$$\kappa_q = E[L_{q\;t+1}] \;\; / \; \sum_{q=1}^{s} E[L_{q\;t+1}] \;\; .$$

When calculating the aggregate region-wide measures of regional income and employment in equations (4.24) and (4.26), it should be recalled that evaluating the impacts of alternative strategies based on different assumptions about the anticipated growth of exogenous final demands by sector will require a recalculation of the sectoral weights, ($\alpha$ in equation (4.14)), the income weights ($\gamma$ in equation (4.25)), and the employment weights ($\kappa$ in equation (4.27)).

**4.6 SOME COMPARISONS WITH OTHER STUDIES**

VAR-Y and VAR-L in equations (4.24) and (4.26), respectively, are measures of regional economic instability (REI) as presented in equation (2.3) in Section 2.4. In some studies on economic diversification, VAR-Y and VAR-L have been called the 'portfolio variance' of a region's income and employment. In previous studies, VAR-Y and VAR-L were measured based on observed levels of sectoral income or employment. In this study, VAR-Y and VAR-L are *ex ante* estimates based on a structural model of a regional economy.

In past applications of the portfolio theoretic approaches to economic diversification, the expected growth and variance of sectoral income or employment by sector were based on observed levels of sectoral income or employment (the portfolio variance approach uses trend values to calculate the variance, and then disregards the information on trends). The observed levels of sectoral income and employment were not based on a model of a regional economy. Instead, as pointed out in Section 2.6.2.2, economic structure and performance were, by definition, identical.

According to the model presented in this section, the expected growth and stability of regional income and employment are based on a structural model of the economy. Because of this, the relationship between changing economic structure and performance can be modelled by simulating feasible structures. The structure in this model measures the growth, stability, and distribution of income and employment as functions of the growth and stability of exogenous final demands.

By measuring the growth and stability of regional income and employment by occupation group, this operational model can also be used to measure distributional impacts. The analysis of distributional impacts is critical when evaluating diversification policies aimed at reducing the region-wide instability of income and employment. By its very nature, the portfolio variance approach to economic diversification is predicated on the assumption that offsetting fluctuations of income and employment by individuals (or individuals aggregated by sector, occupation, etc.) may stabilize region-wide income and employment (equations (4.24) and (4.26)). The region-wide measures of income and employment growth may also be considered (equations (4.20) and (4.21)) when comparing and ranking alternative strategies. However, from an individual's perspective, it is important to know what the impacts are for his or her own income and employment stability (equations (4.22) and (4.23)) and growth (equations (4.16) and (4.18)).

In some, and possibly many, cases, there will be a divergence between the public and private rankings of alternative strategies. Hence, it is important for the regional planner to present the political process with as much information as possible about the growth, stability, and distributional impacts of alternative sectoral diversification policies.

In the case of conflicting public and private rankings of alternative strategies, the region could possibly organize an institutional mechanism for actual (as opposed to hypothetical) compensation by winners to losers. In this manner, an analysis that combined occupation-level results with region-level results could be used the guide the region towards achieving maximal social welfare.

## 4.7 PROJECTING LABOR DEMANDS

Planners can use the operational model to match projected occupation-specific labor force demands with the existing regional labor force, and to analyze anticipated surpluses and shortfalls of different occupation groups. Actually, the operational model is, in essence, a regional labor demand projection model.

In the model it is assumed that laborers within a given occupation group are mobile between sectors, and that they can respond to changing levels of sectoral final demands. It is also assumed that any positive changes (i.e., positive trends and positive deviations from the trends) in regional employment results in either: (i) the employment of residents who were unemployed in the base period, (ii) in-migration, or (iii) new entrants into the labor force. The model thus implicitly assumes that these labor resources 'disappear' when there are negative changes in regional employment (negative trends and negative deviations from the trends).

The model could possibly be extended to interact with a linear programming subroutine that models the labor force, using different assumptions about labor availability by occupation (e.g., regional labor force constraints, in- and out-migration patterns, and in- and out-commuting patterns), and the mobility of labor between occupation groups (which might be promoted by training or manpower development programs).

### 4.8 MEASURING DIVERSITY

Up to this juncture no measures of sectoral diversity or occupational diversity have been used in the analysis. In the context of the approach to regional economic diversification presented in this study, measures of sectoral diversity, such as the entropy or ogive indices of sectoral concentration, portfolio variance, national-averages, per cent durable goods, region size, etc. can be used as descriptive statistics. That is they can be used to describe different aspects of a region's economic performance or structure, but not as comprehensive measures of either performance or structure.

These measures of diversity should be used as summary descriptive statistics and not in the comparison or ranking of alternative strategies. Alternative strategies should be compared and ranked based on their respective contributions to a region's social welfare, which in this model are measured in terms of the growth and stability of regional income and employment.

If region-specific empirical research indicates strong relationships between some measure of diversity of performance and economic structure, then it may be possible to use diversity as a guide in regional planning. This will require special attention to the aggregation, standard, and weights used for constructing diversity measures based on goodness-of-fit.

The entropy or ogive indices can be used to measure the distributional equity of income, if this is considered a measure of a region's social welfare. The 'Gini index' and the 'Thiel index', which are equivalent to the ogive and entropy indices, respectively, are widely used measures of distributional equity. This was mentioned in Section 2.6.2.1. To measure the distributional equity of regional income, occupation groups are ordered by average earnings per worker, and the shares of each occupation group in terms of regional employment and regional income need to be calculated.

**4.9 CONCLUSION TO THIS CHAPTER**

As is often the case, the transition from a conceptual model to an operational model entails simplifying assumptions. As was forewarned on several occasions in Chapter 3, the operational model presented in this chapter is such a case. However, if properly synthesized, Chapters 2, 3, and 4 can provide planners with a flexible conceptual and analytical framework to address the issues associated with regional economic diversification.

The operational model presented in this chapter is particularly well-suited to implementation using the IMPLAN input-output model, which was developed by the Forest Service of the United States Department of Agriculture (USDA). IMPLAN is an extended input-output model which includes social accounts, and can be constructed for any county-defined region in the United States. "Its underlying structure is relatively simple, resembling standard input-output models found in regional economics textbooks [Crihfield and Campbell (1991), p.2]."

Due to its extensive national-level database (which can be disaggregated to the county-level using $p^A$, $p^C$, $F_D$, and $F_C$), its ease of handling, and the availability of a software version, IMPLAN has been widely used for economic impact analysis. IMPLAN also provides numerous tables and reports about a region's baseline economic structure and performance, and simulated economic structure and performance [Crihfield and Campbell (1991); Palmer et al. (1985)]. See Painton (1991), and Rose et al. (1988), for details about the application of IMPLAN using social accounts.

# CHAPTER 5 SUMMARY AND CONCLUSIONS

"Seeking diversified viewpoints on the appropriate strategy for area development, is, I believe essential. Seeking diversification of the rural economy is, in my view, not essential for its future prosperity [Newman (1987), p.87]."

## 5.1 SUMMARY AND CONCLUSIONS

Since the early 1970's, there have been significant changes in the economic structure and performance of many regions in the United States. This restructuring process has been driven by rapid changes in consumer demands, production technologies, and trade flows. Many regions are facing crises due to their inability to adjust to the changing economic conditions.

Rural regions, in particular, have been affected by these changing economic conditions. Many rural regions are faced with economic decline and instability of income and employment in traditionally dominant sectors. As a consequence, there is unemployment and/or underemployment of immobile labor and out-migration of mobile labor. In addition, economic prospects for residents are limited by an occupation mix concentrated in low-skill jobs, while higher-skill jobs in new sectors require in-migrants. The restructuring process taking place in rural regions is characterized by uneven distributional impacts among individuals, households, occupations, and sectors.

Some recent studies on rural development advocate economic diversification as a solution to the economic problems faced by rural regions. These prescriptions contain the assumption that economic diversification (i.e., change in economic structure) can lead to favorable changes in the growth, stability, and distribution of income and employment (i.e., improvements in performance). In fact, there is a widespread belief that economic diversification is a 'panacea' to a plethora of economic problems. Thus, planners and policymakers in many rural regions have contemplated or initiated economic diversification policies expecting improved performance.

At the same time, some other studies on rural development conclude that economic diversification has not necessarily led to improved performance. From both sides of the debate, advocates and detractors agree that the subject of economic diversification is a major topic of concern for the formulation of rural development policies, and that more information is required about the process of economic diversification and its relation to performance.

Since the early 1980's there has been a process of decentralization of economic and political responsibility that makes regions more accountable for their own social welfare. Thus, planners and policymakers in many regions have expressed the need for conceptual and analytical frameworks to improve their understanding of past and present economic developments, and to plan for the future. With appropriate conceptual and analytical frameworks the impacts of alternative development strategies could be evaluated.

For this study, the regional science literature is reviewed in order to assess the conceptual and analytical frameworks used to address the subject of economic diversification. During the past sixty years there have been numerous attempts in the regional science literature to define and measure economic diversification in terms of a 'balanced economic structure', and to test hypothesized relationships between economic diversification and performance. However, the meaning of economic diversification, its measurement, and its relationship to performance are ambiguous, confusing, and in some cases conflicting.

Some of this ambiguity, confusion, and conflict occurs because past studies define and measure economic diversity, which is a static concept; instead of the process of diversification, which is a dynamic concept. However, this distinction is not always made clear in the literature. In addition, different economic theories (e.g., trade theory, economic base theory, regional business cycle theory, location theory, and economic development theory) and finance theory (e.g., portfolio theory) use somewhat different concepts of diversification. The different concepts of diversification imply different performance goals, and that there may be tradeoffs between growth, stability, and distributional goals.

In general, past studies in the regional science literature have not provided policy-relevant conceptual frameworks or analytical tools to address the economic problems faced by rural regions, because: (i) the widely used definitions and measures of economic diversification or diversity do not provide guidelines for planning changes in economic structure to achieve goals of performance, (ii) the functional relationship between changing economic structure and performance is unclear, (iii) attention is focused on the relationship between diversity and stability, and the relationship between diversity and other measures of performance, such as growth and distribution, are ignored, (iv) the changes in a region's population that take place during the process of economic diversification are ignored, and (v) a model of the relationship between changing economic structure and performance is not provided. In view of all these shortcomings, it can be concluded that past studies on economic diversification do not provide an appropriate conceptual or analytical frameworks to address the economic problems faced by rural regions.

The major objectives of this study are to: (i) improve the understanding of what is meant by economic diversification and economic diversity, (ii) provide a comprehensive conceptual framework for region-specific analysis of the relationship between changing economic structure and economic performance measured in terms of growth, stability, and distribution, and (iii) construct an operational model of a regional economy that can be used to assess the impacts of alternative development strategies. This study should lay the foundation for future empirical studies.

A new approach to economic diversification is presented in this study. The approach attempts to sort out the overlaps, contradictions, and gaps among the different economic and finance theories, and the different definitions and measures of economic diversification. The subject of economic diversification is addressed in the context of the question: "What is the relationship between a region's changing economic structure and performance?" This dynamic concept of economic diversification was derived from the development economics literature, where the term diversification is used to describe the process of economic transformation.

According to the approach taken in this study, the 'ideal' balance of economic structure is determined by examining the relationship between economic structure and performance. The elements of economic performance (e.g., growth and stability of income and employment) help determine a region's social welfare. That is, social welfare is the standard for measuring economic structure.

In the conceptual framework and operational model, the terms diversification and diversity are intentionally marginalized, so that the focus is always on the relationship between economic structure and performance. This study suggests that the popular definitions and measures of economic diversity should be used as descriptive statistics of a region's economic structure or performance, not for purposes of analysis.

The conceptual framework and operational model presented in this study are based on comprehensive measures of a region's economic structure and performance. A social accounting matrix (SAM), which combines input-output accounts, social accounts, and accounts of trade flows (i.e., the circular flow of regional economic activity) is used to construct material balance equations of sectoral output and household income.

Using the material balance equations, an extended input-output model is developed. This SAM-based structural model of a regional economy serves as the foundation of the conceptual framework and operational model. The model explicitly depicts the functional relationship between economic structure and performance. The region's demand, production technologies, and trade flows are included as part of economic structure. Economic performance is measured as the growth, stability, and distribution of regional income and employment, by occupation group.

The structural model is used to analyze the relationship between economic structure and performance for a given time period, and to analyze changes over time. Growth, stability, and distributional impacts were considered simultaneously. By doing this, potential tradeoffs can be explicitly addressed.

To identify the structural sources of growth and stability, the SAM-based model is decomposed at different points in time. This comparative statics approach does not detail the dynamics of temporal change, but does provide insights into the process of temporal change. By decomposing a SAM-based model, as opposed to an input-output model, it is possible to analyze structural sources of growth and stability in terms of both supply and demand factors, instead of only supply factors (i.e., multiplier analysis).

Different sources of growth and stability of sectoral output are identified based on the decompositions. The sources of sectoral output growth include the impacts from changes in regional purchase coefficients of intermediate demands, input-output coefficients, regional purchase coefficients of household final demands related to induced impacts, household consumption patterns, occupation-household relations, income-occupation coefficients, occupation-output coefficients, regional purchase coefficients of household final demands related to exogenous income, household consumption patterns related to exogenous income, exogenous income, and sectoral final demands. The sources of sectoral output stability include the variance of each of the sources of growth listed above, and all of their covariance terms.

The decomposition technique can be used to measure the structural sources of growth and stability for different economic, social, environmental, and other measures of performance, if they can be modelled as a function of sectoral output. Sectoral outputs are, in turn, a function of exogenous final demand. In this study, the structural sources of income and employment growth and stability are modelled by occupation group. The decompositions of sources of the growth and stability of output, and the accompanying economic interpretations, provide new insights into the restructuring process. Alternative development strategies can be modelled using this conceptual framework.

The concept of a 'probabilistic' input-output model is introduced to measure the expected growth and stability of sectoral output. In contrast to past studies based on 'stochastic' input-output modelling, which focus attention on the accuracy of the estimates of the model's structural parameters, probabilistic input-output modelling analyzes the stochastic variables that affect a region's economic structure and performance.

The probabilistic input-output model is compared to the standard deterministic input-output model, which holds the sectoral output multiplier matrix fixed while allowing exogenous final demands to vary. It is found that for projections of growth of sectoral output, the standard input-output model can be considered a stochastic model with a time invariant multiplier matrix, and time variant exogenous final demands. However, for projections of stability of sectoral output, it must be assumed that the multiplier matrix is fixed, although the exogenous final demands can be stochastic.

The operational model, which is constructed using a fixed multiplier matrix, quantifies the relationship between: (i) the anticipated growth and stability of exogenous final demands, and (ii) the anticipated growth, stability, and distribution of endogenous income and employment. This is referred to as a 'probabilistic' version of the standard input-output model.

For the growth and stability decompositions it is assumed that the multiplier matrix is stochastic, like exogenous final demands. Hence, the transition from conceptual framework to operational model requires simplifying assumptions about the multiplier matrix, as described above. While developing the conceptual framework, these assumptions were made explicit. The difference between a 'full' information and a 'partial' information operational model are made transparent. In some cases, the operational model can be adjusted to compensate for the 'missing' information, by incorporating anticipated changes in the multiplier matrix a priori. When applying the operational model, alternative development strategies that involve changes in the multiplier matrix can be modelled by calibrating the base-period economic structure.

The operational model focuses attention on the distributional impacts of changing economic structure and performance. In contrast to previous studies on economic diversification, the relationship between a region's social welfare, and the aggregation scheme and accounting stance used in the analysis of economic impacts are explicitly addressed. There are explicit social welfare criteria for comparing and ranking alternative development strategies. Furthermore, there is an explicit framework to separate occupation groups into sub-groups that differentiate between residents and in-migrants, and employed versus unemployed residents.

This separation into sub-groups has important implications for planning purposes and for the measurement of distributional impacts.

The operational model also focuses attention on the differences between 'what a region makes' (i.e., what the region produces), and 'what a region does' (i.e., the region's human resource base). The final demands are measured in terms of sectors--what a region produces, and economic performance is measured in terms of occupation groups--what a region does. This distinction is important for planning purposes and for the measurement of distributional impacts. For planning purposes, the operational model can be used to project labor demand in order to match anticipated labor force demands with the existing labor force. Measuring the growth and stability of regional income and employment by occupation group facilitates the comparison of winners and losers, because individuals are often identified by their occupation (as opposed to their sector).

The operational model presented in this study is well-suited to many popular input-output application packages. The model is particularly well-suited to the IMPLAN input-output model, developed by the Forest Service of the United States Department of Agriculture. IMPLAN has a national-level database that can be disaggregated to the county level, and the base-period model can be adjusted to simulate alternative development strategies.

## 5.2 SUGGESTIONS FOR FUTURE RESEARCH

One of the objectives of this study was to lay the foundation for future empirical studies, and the primary suggestion for future research is to apply the conceptual framework and operational model presented in this study. Simulations can be carried out for purposes of evaluating alternative development strategies and/or for evaluating relationships between changing economic structure and performance.

There are some important statistical issues that need to be addressed before empirically applying the model. The critical statistical issue is how to measure the expected growth and stability of exogenous final demands. The probabilistic version of the standard input-output model depends on these estimates.

By construction, the conceptual framework and operational model are parts of a holistic approach to economic diversification. Hence, future research should also be geared towards relaxing some of the simplifying assumptions used in the transition from conceptual framework to operational model.

The probabilistic version of the standard input-output model is a projection model that assumes linear production and consumption functions, a fixed sectoral output multiplier, fixed prices, no resource constraints, and no substitution among inputs. Considering the detailed growth and stability decompositions that were presented in Chapter 3, in some circumstances the assumptions of fixed, linear relations may be unrealistic. Many of the changes described in the growth decompositions are nonlinear, and the covariances described in the stability decompositions are, by definition, nonlinear relationships among the variables. The conceptual framework and operational model presented in this study can assist researchers and planners by directing their efforts towards identifying and modelling some of the nonlinearities.

It may be possible to use the conceptual framework and operational model as a bridge between the standard input-output model, dynamic input-output models, and computable general equilibrium models. As pointed out in Chapter 3, the decomposition technique used in this study can provide some indication of the direction and magnitude of economic impacts, and can serve as a guide for models that do incorporate behavioral, technological, and institutional relations as well as assumptions about the function of markets.

### 5.3 CONCLUDING REMARK

"Just because some of us can read and write and do a little math, that doesn't mean that we deserve to conquer the Universe. THE END."
Closing statement by Kurt Vonnegut (1991), in Hocus Pocus.

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# VITAE

Paul Bennett Siegel was born in Baltimore, Maryland on January 21, 1953. Paul entered the University of Maryland, College Park, Maryland in September 1970. In May 1976 he earned his B.S. Degree in Horticulture, and in August 1977 earned his B.A. Degree in Jewish Studies.

In November 1978 Paul began his graduate studies in agricultural economics at Hebrew University of Jerusalem, Rehovot, Israel. After completing the course requirements, in June 1981 Paul began working as an Agricultural Economist and Planner in the Israeli Ministry of Agriculture. In October 1982 Paul received a two-year appointment as Executive Officer and Senior Economist for AIM Consultancy, Ltd., Lusaka, Zambia. After returning to Israel in October 1984 Paul worked on his M.S. thesis. In October 1985 he earned his M.S. Degree in Agricultural Economics from Hebrew University of Jerusalem. The subject of the thesis was: "A Dynamic Farm Level Planning Model for Optimal Feedlot Production and Marketing in Israel."

From January 1986 to May 1987 Paul worked as a Researcher at The World Bank, Washington, D.C. During July and August 1987 he worked as a Consultant for The World Bank and had several subsequent short-term consultancy assignments from 1987 through 1991.

In September 1987 Paul began his Ph.D. studies in agricultural economics at Virginia Tech, Blacksburg, Virginia. He earned his Ph.D. Degree in Agricultural Economics from Virginia Tech in January 1992. The subject of the dissertation was: "The Relationship Between Changing Economic Structure and Performance: Diversification, Diversity, Growth, Stability, and Distributional Impacts."

Upon completion of his Ph.D. studies Paul will assume the position of Assistant Professor of Rural Economic Development, Department of Agricultural Economics and Rural Sociology, University of Tennessee, Knoxville, Tennessee.