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STRATEGIC REGIONAL POLICY

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EDITORS

PART I

WARSAW 1985

SYSTEMS RESEARCH INSTITUTE
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STRATEGIC REGIONAL POLICY

Paradigms,Methods, Issues and Case Studies

A. Straszak and J.W. Owsiński
editors

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PART I

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I. A REGION AND A FIRM

STRATEGIC PLANNING BY REGIONS
VERSUS STRATEGIC PLANNING BY FIRMS AND HOUSEHOLDS

by

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INTRODUCTION*

"Strategic planning" has recently become an intriguing concept in regional analysis, but of course the notion has been an important concept in analyses of firms and households for much longer. In this paper I raise the question: To what extent can the analytical approaches to modeling firms' and households' strategic planning be applied to regional strategic planning?

The paper has two main parts, and each of the two parts has a number of sections.

In Part I, "General Considerations," I discuss in a rather general way the question of whether models developed for the firm can be applicable to the region. By model, I mean a decision rule. By "applicable," I mean a model that can be useful to a regional decision-maker who has some range of powers to affect, but not completely determine, economic activity. I refer to that decision-maker as a regional "planner," but I have in mind what others might call a regional policymaker, and use the word planner merely as a personal preference. (I do not mean, by regional planner, a person who does "city and regional planning" as that term is understood in most Western countries.) In this first part, I concern myself solely with private firms, to the exclusion of state enterprises or nonprofit private organizations.

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In Part II, which is much longer, I probe more deeply, and at great length, into one particular model for strategic planning by a household, the Markowitz portfolio model, that has been suggested as a useful tool for regional planning. In this second part I hope by examination of the specific example to add perspective on the whole question of the applicability of firm and houehold models.

In the rather general Part I, there are several sections. In a very short first section I point out that, a priori, theories originally developed for firms have some relevance for regional planning. In other words, to put it briefly, the whole idea is not nonsense--it is worth looking into. In the second section, I counter the first, by pointing out some fundamental differences between a firm and a region, particularly the differences between the "client" of the firm's manager and the "client" of the regional planner, and the greater complexity that is required in a model of a region as a result of the difference in the client. The result of this balancing act on my part is that certain models may be relevant, but must be used with great care and without excessive expectations. In the third section, I briefly discuss two concepts of strategic planning, learning and exit, that are relevant for both firms and regions.

In Part II, there are also several sections. In the first, I describe the version of the portfolio model as developed by Markowitz and others for a household. In the second, I raise the problems inevitably encountered in applying that model to a region--the things that give one pause before proceeding. In the third, after having paused, I sketch out a regional application in some detail. In an appendix to the paper, I describe a possible empirical approach to implementing the regional version of the portfolio model.

PART ONE: GENERAL CONSIDERATIONS

1. The A Priori Case

The a priori case can be put rather simply, and very abstractly. Microeconomic models of the firm are subsets of a more general set of models for rational decision-makers: models of decisions, under constraints, with a view to maximizing some objective function. The common framework is illustrated by the fact that many mathematical techniques developed for optimizing behavior have extensive bodies of literature on their applications in firms and on their applications to public or nonprofit private decision-makers. Mathematical programming is an obvious example; the theory of optimal investment decisions is another. However, it does seem necessary to specify a context in which the regional planner has a considerable range of powers to affect economic activity, and that he can be assumed to attempt to optimize some specified objective function.

The differences between public and private applications are in the nature of the objective function, and in the nature of the constraints that must be met by the decision-maker. I explore these differences in greater length in the third section below.

2. Three Contexts of Planning

It is useful to distinguish three different contexts in which a "regional planner" operates. Actually, each of these contexts implies a different kind of regional planner.

The first planner, here called X, plans for his own region alone, and without regard to the effects on other regions or the nation. He naturally operates under constraints, some imposed by national planners and some imposed by the regional and national and international economic structures, but within those constraints X maximizes an objective function that contains only his own region's welfare indicators.

The constraints X operates under may be very tight. He is unlikely to be able to initiate monetary policy; perhaps he cannot even run a regional budget surplus or deficit; the industries in his region may sell or buy inputs in highly competitive markets; people may move freely over his region's borders. On the other hand, sometimes the constraints are not as severe as on a competitive firm: in particular the industries in his region may have considerable market power.

X corresponds to, in the world of firms, the manager of an independent firm or the manager of a single division of a multidivisional firm.

The second planner, Y, is a national government planner, who makes decisions that affect the nation and a single region. Y has more instruments at his disposal than X, and takes actions with regard to how they affect the region and the nation, but without regard to how they affect other regions. Although Y has more instruments, we would expect that only when using some of them can she legitimately concentrate on one region. For example, in making monetary and exchange rate policy, she must take account of all regions. Is this context, then, purely hypothetical? No, there are relevant real-world examples. Some national policy instruments have significant effects on only one region. For example, one region may have the nation's only natural resources of a certain type, and Y may believe that the effects of natural resource policy are so diffuse over other regions that she need not keep track of them. Or the region may have the nation's only concentration of some other industry, important for the nation's international economic policy, but with no concentrated effect on any other region.

The corresponding business manager would be a central office manager in a multidivisional firm, who can legitimately set policy for one division at a time.

The third planner, Z, is a national planner, who is like Y except that he must take account of the effects of policies on more than one region. He has to do this because of technological and market interdependencies, externalities, public goods, migration of people, portfolio effects, and so on. Again, the corresponding firm planner is a central office manager in a multidivisional firm.

In the rest of my discussion I am implicitly assuming the first context, that of X, unless stated otherwise.

2. <u>Important Differences Between the Firm and the Region</u>

<u>Difference in the Client Group</u>. As just suggested, one important difference is in the objective function. But perhaps a better way to introduce this difference is to discuss the difference in the "client group," which underlie the differences in objective function.

Consider a rather abstract form of the microeconomic theory of the private firm, a firm that is a coporation managed by nonowners, and that has equity shares traded in a competitive capital market. The firm's manager acts on behalf of the current owners. He is assumed to do the best that he can do for them by maximizing the market value of the firm. Maximizing market value is what is really meant by economic theorists who refer to "profit maximization" as a shorthand expression for the goal of the manager. By striving for that goal, he makes the greatest contribution in his power to the owners' wealth. Individual owners who have as much wealth as possible have the greatest flexibility to allocate their wealth, over different consumer goods and services and over different time periods, so as to maximize their utility. The manager need not concern himself with any characteristicistic of any owner's utility function.

For that reason, he need not even know who the owners are. He concerns himself solely with doing all that he can to increase market value. The ownership of the firm may change continuously, if equity shares are traded, but at every moment of time the manager best serves the people who happen to be owners at that moment by increasing market value. If an owner abandons ownership by selling shares, he is assumed to do so voluntarily, and he is assumed to have improved his situation, over the alternative of holding on to the shares. If a person becomes a new owner by buying shares, he is also assumed to have done so voluntarily and to have improved his situation, over the alternative of not holding the shares. Thus, the manager need not worry about who the owners are.

What about managerial mistakes? Owners cannot, practially speaking, discharge managers quickly. But they have the alternative of selling shares, and so they can adjust to an unwelcome mangerial policy fairly quickly. They cannot anticipate perfectly managerial mistakes, and there are some transactions costs to selling. Therefore, owners are often hurt by managerial mistakes. Nothing in the theory of the firm says that managers always succeed in their goal. But, if owners are watchful, they can limit the amount of harm.

All this can be summed up succinctly: No owner is an involuntary participant in the firm for very long.

Therefore, the manager need not worry about the impacts of his managerial actions on individual owners: he worries only about the aggregate effect, as expressed in market value of the firm, and not about the distribution of results over owners.

Immediately, the contrast to the public planner becomes apparent. "Distribution" is the key. The public planner, including the regional planner, feels obliged to worry about distribution. Why? Because the adjustment costs--both monetary and time costs--for a dissatisfied resident of a region are far greater than the adjustment costs for a dissatisfied owner of a firm. In some centrally planned economies, where for national policy reasons migration between regions is sharply limited, the adjustment costs may be nearly infinite--there is no practical way for a person to leave a region. Even if he can, there is less chance that he can leave the country, so his choice of regions to move to is limited.

Thus, in the case of a region, we may have many residents who are unwilling participants in the regional economy for a long time--they are "trapped," as it were. Because of that, regional planners feel concerned for the welfare of many specific individuals. The distribution of income matters.

Now, of course, in many countries some people can, and do, leave their region. Others come into the region. The population making up a region is not stable over time. A very interesting problem is raised by the possibility that some people leave only after suffering considerable cost due to some regional event or policy. Assume that a policy decision is made at time $t = t_o$, which creates some risk. It may be known that some proportion of present residents (but not exactly who) will have to leave the region before t_n, the end of the planning period, and that some will leave only at considerable cost (i.e., leaving is their optimal adjustment to a bad situation). Some other people will migrate into the region before t_n, partly because they fill jobs in industries that expand because of the policy. What collection of persons is the "region"? Is it: a. Persons living there at t_o? b. Persons who will live there at t_n, including inmigrants and excluding outmigrants? c. Persons who live there at t_o and remain through t_n, excluding both inmigrants and outmigrants? or, d. All persons who live there at any time, but counted only when they are there?

Conventional regional income data are for definition d. But politically, definition a seems more relevant. For historical analysis--analysis of how well a region did in terms of some welfare indicators--probably the best definition is d, plus people who suffered high costs when they left, and counting those latter people for the entire planning period (even though they lived part of it out of the region). That would complicate empirical analysis of history considerably, because available income data don't include people who have abandoned the region in despair.

Market Values Are Not All That Count.

The dominant model of the firm assumes that a single monetary indicator, market value, is sufficient to guide managers. There is some literature on situations where managers maximize their own utility function, which includes variables ("perquisites") that conflict with market value. But those situations are still seen as exceptions to the general pattern. The dominant model is of the situation where owners derive no utility directly from ownership, but only indirectly through their wealth.

Clearly it is different for the public decision-maker. In one whole body of theory, if not in any real-world economy, the raison d'etre of the public planner is the need to substitute other information for market values. In real-world economies, this rationale is not as dominant as in certain abstract welfare economics theory: public planning is justified by equity concerns, or overall economic development concerns, as well as by externalities and public goods. Those concerns would prompt public planning and public enterprises even in a situation where market prices accurately reflected all benefits and all opportunity costs. Nevertheless, the need to incorporate nonmarket values is at least one of the most important reasons for public planning.

It would be superfluous to review all the theory of normative planning to reflect nonmarket values. My point here is the rather obvious one that such planning is inherently more complex than the planning for a firm. The complexity raises a serious question as to whether firm-based models have enough applicability to warrant taking them as first approximations, and then modifying them to deal with nonmarket values. That procedure usually involves the calculation of pseudo-market values, or "shadow prices," of benefits and costs, based on market evidence for similar or competing products, on land values, on special bidding games and surveys, etc. Without detracting from the value of that procedure where it can be used, it seems to me that in some applications it is probably doomed to futility. It may well be better in those cases to start from a totally different perspective--to build from the start an explicitly public planning model, that does not put such a high presumption on economic efficiency and the suitability of monetary equivalents, but recognizes the practical demands of the political process.

Firm-based models get extremely problematical when public decisions require incorporation of both income distribution and nonmarket values. For then the distribution of total income, pecuniary and nonpecuniary, depends on the great heterogenity of individual persons' or groups' nonmarket valuations.

3. Two Brief Examples

I conclude Part I by discussing very briefly two examples of how firm planning concepts are relevant to a region.

Learning.* The concept of "learning by doing" as an element of a firm's planning has some relevance to a region's planning. All three kinds of planners, X, Y, and Z should take it into account when a new industry is being developed in a region. The rate of learning is relevant for all of the following:

--Calculation of the capital cost of industrial development. It may be that a major part of capital cost is the temporary losses incurred during the early stages of development. The faster is learning, the less are those costs.

--Prediction of the market for a new industry's product and profits earned in it. If learning reduces costs and/or increases quality, then some combination of a wider market and higher profits are possible. The size of the market may be relevant for foreign exchange earnings; profits may more important for savings. The rational planner will determine the time path of the price-cost margin so as to optimize the combination of the two.

--The opportunity for "preemptive investment." It is possible for a region to benefit much from "being first" or by preempting the market, if learning by doing occurs. The prospect of rapid learning may lead a region to take a greater risk than if learning is slow.

These three aspects of learning are closely interrelated, of course. For example, if the capital cost is reduced by learning, then the risks of attempted preemptive investment are lower; if the market is expanded, the returns from taking any given risk is higher.

Learning is definitely a phenomenon that can occur in an entire industry or even in a number of industries in a region. The rate of learning affects the rate at which backward and forward linkages occur, and the rate at which economies of agglomeration occur. Therefore, learning is a concern for all three kinds of planners. Of course, a firm cannot appropriate for itself all the effects of its own learning. Many of the favorable effects will be through general training of workers rather than specific training, to use Gary Becker's distinction. The regional planner cannot judge the value of learning by a firm solely by the effects on the industry's costs and profits.

Moreover, the planner, like the firm's manager, must be very careful not to confuse cost reductions due to learning with cost reductions due to other things which are happening during the development process.* Those other things include economies of scale, economies of scope, increasing exploitation of market imperfections as the size of a firm increases (e.g., monopsony in capital or other input markets), research and development, and exogenous technological change. As Ross points out, managers may expect cost reductions to come from learning, when in fact the cost reductions can come only from those other sources. Then the firm will not realize cost reductions merely by expanding output; it must take other, costly actions. Indeed, it may actually reduce profits by forcing rapid output growth.

<u>Exit</u>. Exit from a market is a crucial strategy. Anticipating the opportunity to exit is part of strategic planning. Knowing when to exit may be just as important as knowing when to enter. This is true for a region as well as a firm. But the criterion for the region is different.

A firm will exit when the expected return to existing physical capital goods falls short of the opportunity cost of keeping the capital in place and producing with it. In the short run, the opportunity cost may be quite low, especially if the capital goods are very specific to the industry. In that case, the capital cannot be sold for very much, and so the opportunity cost of keeping it in place is

*This section relies heavily on David Ross, "The Significance of Learning in Reducing Costs," Department of Economics, Williams College, October 1984.

low. As long as maintenance cost is low, continued production will be profitable even though the firm suffers accounting losses. The short run may in fact be rather long in time, and so firms often remain in an industry for extended periods during which they earn accounting losses. However, as time goes on, the opportunity cost rises because maintenance costs rise; eventually the firm exits.

The same is true of regions. What has been said about capital goods applies also to a region. But the regional planner must take account of all immobile capital, including human capital, and not merely immobile physical capital. Wage rigidity makes the monetary cost to the firm of hiring unemployed labor higher than the social opportunity cost. Thus the private firm fails to utilize immobile human capital and exits from the region prematurely.

Nevertheless, the regional planner must also know when exit is the right strategy. The decision depends crucially on the mobility of human capital.

<u>Conclusion</u>. The overall picture is mixed. Firm models--decision rules--for strategic planning are useful. They are suggestive. But they must be used with caution.

But if used with caution, they <u>are useful</u> with caution. Even if a model does not adequately describe present planning practice, or does not encompass all the relevant goals and constraints, it nevertheless can point directions in which planning theory and practice should move. It may signal attention to new variables, new planning tools, and new data the regional planner should develop.

PART II. THE PORTFOLIO MODEL

This section of the paper outlines in detail the possibilities of application of one specific model from the literature on firms and individuals to a region's decision-making.* That model is the optimal portfolio selection model developed by Markowitz (1952, 1959). It models an individual investor's strategy to reduce instability (in the sense of <u>unexpected</u> fluctuations) in income. It is an application that has already attracted some attention in the regional economics literature [Conroy (1974, 1975a, b), St. Louis (1980), Barth, Kraft, and Wiest (1975), Jackson (1980), Prosperi and Sjursen (1980), White and Chou (1980). For a review of such literature, see Bolton (1983)]. However, in my opinion, previous applications have been limited in the types of real income included in the model, and limited in the sources of risk allowed for. Nor has the portfolio approach been used in evaluating proposed new public and private investment projects in regional benefit-cost analysis. That is in spite of the fact that the portfolio approach to an individual or firms's decisions is highly suitable to handle the evaluation of a single new asset that is proposed to be added to an existing collection of assets held by the investor.

The welfare economics basis for a regional government's concern with diversification is as follows. First, economic efficiency inevitably

*This part of the paper is based on an earlier, much longer paper, "A Portfolio Analysis of Diversification of a State Economy," that I read at the American Economic Association meetings, San Francisco, December 1983 (cited as Bolton (1983)). This work was also supported in part by a grant from the General Electric Foundation. My thanks to Harry Markowitz, Ralph Bradburd, Mead Over, Sheafe Satterthwaite, Tim Fries, Julie Schor, Seymour Mandelbaum, Masahisa Fujita, Tony Smith, Mira Baron, Hisayoshi Morisugi, Yasoi Yasuda, Yoshitsugu Kanemoto, and others in seminars at Williams College, University of Pennsylvania, Gifu University, and Tsukuba University.

requires some public goods to be financed at the regional level; individuals' welfare is affected by unexpected variability in the provision of such public goods. Thus, a regional government that is representative of its residents should be concerned with the trade-off between the expected value and the variance of the real income created by its public goods production, similar to the way individuals are concerned with the trade-off between expected value and variance of their private income.

Second, a regional government may be able to reduce instability in private sources of income more effectively than individuals can achieve on their own (e.g., by private insurance or financial asset diversification). It may be able to do this through various policies on infrastructure, incentives to private employers, tax structures, etc. However, the scope for this will be the smaller, the more effective are the insurance schemes and financial asset diversification open to individuals.

There are several sources of instability in regional income. Again, note that instability means unexpected fluctuations (so that, for example, regular seasonal fluctuations do not count as instability). One source is the national business cycle. This is only one, but an important, source. A second one is the increasing integration of the world economy and capital markets, which broadens the range of unexpected events which can affect a region. A third, relevant in some regions, is dependence on energy and other resource extraction, which makes a region vulnerable to unstable energy markets and policies.

In some regions, instability in private incomes is aggravated by fluctuation in public goods output, because public goods must be financed by taxes on private incomes. In other regions, however, the power of a regional government to run a budget deficit may introduce some stabilizing forces.

These arguments suggest the utility of a portfolio model for a region, but one that allows some of the instability to be independent of the national business cycle, and that considers real income created by financing public goods.

My effort in this section is exploratory and theoretical; my empirical work is still in progress. The appendix outlines a possible empirical approach.

1. <u>The Portfolio Model Of An Individual Investor</u>

In this section I describe basic financial portfolio analysis, with references to possible application to a region. [Besides Markowitz (1952, 1959), other useful references are Fama and Miller (1972), Fama (1976), Sharpe (1970), Francis and Archer (1971), and Elton and Gruber (1981)].

In the model, an investor has some amount, K*, of wealth, which he can invest in one or more of N capital assets. There are constraints--maximum or minimum amounts--on the amounts he invests in some assets. Each asset i has a known probability distribution of rate of return, r_i. Her utility is a function of income from the assets over a single period, she maximizes expected utility, and she is risk averse. I assume her preferences can be adequately described by two parameters of the probability distribution of income, the expected value, $\bar{r}$, and the variance, σ^2. Recent work has shown that this traditional assumption is a surprisingly good one, so I maintain it in this exploratory effort.[1]

A portfolio of assets has mean return, $\bar{r}_p$, and variance, σ_p^2:

(1) $\bar{r}_p = \sum_i x_i \bar{r}_i$

(2) $\sigma_p^2 = \sum_i \sum_j x_i x_j \sigma_{ij} = \sum_i x_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} x_i x_j \sigma_{ij}$

where: $x_i = K_i / K^*$, the proportion of K* invested in asset i ($\sum_i x_i = 1$ and, in the basic model, $0 \leq x_i \leq 1$ for all i) and σ_{ij} = the covariance of returns between asset i and asset j. All sums run from 1 to N unless otherwise indicated. An omitted asset has $x_i = 0$.

Portfolio variance is the sum of all N terms in the following symmetric covariance matrix:

$$
(3) \quad
\begin{array}{ccccc}
x_1^2\sigma_1^2 & x_1x_2\sigma_{12} & x_1x_3\sigma_{13} & \cdots\cdots & x_1x_N\sigma_{1N} \\
x_2x_1\sigma_{21} & x_2^2\sigma_2^2 & x_2x_3\sigma_{23} & \cdots\cdots & x_2x_N\sigma_{2N} \\
x_3x_1\sigma_{31} & x_3x_2\sigma_{32} & x_3^2\sigma_3^2 & \cdots\cdots & x_3x_N\sigma_{3N} \\
\cdot & \cdot & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & \cdot & \cdot \\
x_Nx_1\sigma_{N1} & x_Nx_2\sigma_{N2} & x_Nx_3\sigma_{N3} & \cdots\cdots & x_N^2\sigma_N^2
\end{array}
$$

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1. Expected utility is an exact function of expected value and variance if: 1. The utility function is quadratic; or, 2. All probability distributions of returns are normal. Neither assumption is very satisfactory. Fama and Miller (1972, pp. 261-7) argue that a good empirical assumption is that all returns distributions are symmetric stable functions of the same type (that is, with the same characteristic exponent); then the investor's preferences are completely described by the mean and one other parameter, which is a measure of dispersion related to the variance but not exactly equal to it. (A normal distribution is a special case of a symmetric stable function, and for it the variance is the relevant measure of dispersion). Thus, a two-parameter model is adequate. In addition, Levy and Markowitz's empirical studies of market returns show that a function of mean and variance closely approximates a less restrictive utility function, and if an investor considers only mean and variance she can come very close to maximizing expected utility correctly defined, no matter what her utility function (1979).

The matrix describes the essential structure of the portfolio as far as risk is concerned. Later I'll suggest that a similar matrix for a region is an important description of its economic structure.

By convention, one asset's "contribution to risk," or simply its "risk" in a portfolio is defined as the sum of either one row or one column, the two sums being identical:

(4) risk of asset i in portfolio = $x_i[\sum_j x_j \sigma_{ij}] = x_i[x_i \sigma_i^2 + \sum_{j \neq i} x_j \sigma_{ij}]$

The risk per unit of asset i is the term in brackets in (4), a sum of weighted covariances between x and all assets in the portfolio, including itself; it is denoted by σ_{ip}.

An asset's risk depends on its own variance and on characteristics of all the other assets in the portfolio; this insight is at the heart of the portfolio approach. And this insight is a useful one in regional benefit-cost analysis of proposed investment projects: the riskiness of a proposed project is not a function solely of its own variance, but of also of its covariance with the existing sources of income to the regioin.

Markowitz Diversification

In Markowitz diversification, the investor consciously seeks out low and negative covariances in order to minimize σ_p^2 for any given $\bar{r}_p$. The first asset she chooses will be the one with minimum σ^2 of all those which have $\bar{r}_i$ equal to her target $\bar{r}_p$. She will add other assets only if she can find ones which reduce σ_p^2. However, there is a limited number of financial assets which have very low or negative covariances with other assets, so the Markowitz diversifier can't continually reduce σ_p^2 by adding assets and and still maintain the $\bar{r}_p$ target.

The Risk-Return Trade-Off

The trade-off between risk and return under Markowitz diversification is a crucial concept in portfolio theory. If there are many assets in the available set, all possible portfolios are represented by the area in Figure 1; each point in the set indicates a portfolio (see Bellemore et al. (1979), pp. 163-75, for useful numerical examples). The relevant opportunity locus is EE', and is called the efficiency frontier or Markowitz frontier. It is generated by choosing through quadratic programming the optimal set of x's to minimize σ_p^2 for each possible $\bar{r}_p$. The frontier is continuous if all x's are infinitely divisible, but it may have gaps if there are indivisibilities or other constraints. The number of assets included in an efficient portfolio varies with the problem; it tends to be lowest near either end of EE'. The efficiency frontier is analogous to the budget line in consumer theory; the optimum choice is a tangency between the frontier and an indifference curve (assuming the frontier is continuous).

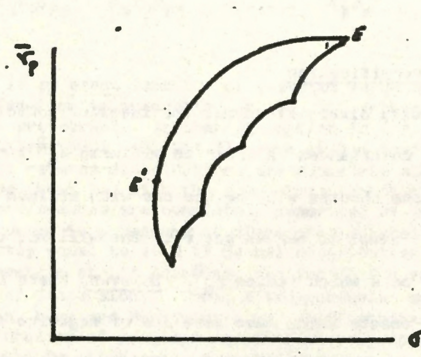

Figure 1

Efficiency Frontier with Many Assets

In any regional application, constraints are crucial and introduce essential realism into the application. They reflect indivisibilities, nonmarketable "assets" which produce real income in the region but cannot be changed by the government, fundamental limitations on the ability of a government to affect the distributions of private income from various kinds of industries, and distributional constraints. Policymakers may try to keep an existing employment source, for example, or existing assets producing public goods, at a certain level in order to protect a group of workers or other residents.

The quadratic programming calculation may appear to be a formidable mathematical task, but it isn't, even if the constraints are quite complicated, and standard (but possibly expensive) computer packages are available [see Elton and Gruber (1981), Sharpe (1971), and Francis and Archer (1971) for details on solution methods]. It may also appear a formidable task to gather the data, and it is! There are N individual variances and $(N^2 - N)/2$ different covariances or correlation coefficients, and the job of estimating them is far more difficult than solving the mathematical problem once the numbers are obtained. In financial applications, security analysts make drastic simplifying assumptions, in order to describe the general correlation structure with many fewer than $(N^2 - N)/2$ parameters. However, I doubt if one can justify the usual simplifying assumptions in the regional application. I return tothis point just below.

One would not expect that a cross-section of observations of r_i received by different investors at one moment of time to produce good estimates of the parameters $\bar{r}_i$, σ_i^2, and σ_{ij}. Common influences on all investors at the moment of time will be so important that the variability across investors underestimates true variance and overestimates the absolute values of covariances. Yet many traditional non-probabilistic measures of regional diversification depend on cross-section data [Bahl, Firestine, and Phares (1971)]. We need time series, and we must supplement them with other data and *a priori* analaysis; in finance, that kind of analaysis is called "fundamental analysis" of an asset.

Index Models

In order to reduce data requirements, financial analysts often assume the covariance matrix has a simple structure. An example is the "index model," in which each asset's returns are assumed to be a linear function of one or a few indexes which are economic variables that affect systematically the returns on all assets. Assets are correlated with each other because they are all correlated with the index(es). For example, in the single index case:

(5) $r_i = a_i + B_i R + e_i$

where a_i and B_i are constant for each i, R is the index, and e is a random error term. B is the "beta coefficient" so important in financial analysis. If we assume that $\bar{e}_i$ is zero, and that covariance (R, e_i) and all covariances (e_i, e_j) are zero , then

(6) $\bar{r}_p = a_p + B_p \bar{R} = \sum_i x_i a_i + [\sum_i x_i B_i]\bar{R}$

(7) $\sigma_p^2 = B_p^2 \sigma_R^2 + \sum_i x_i^2 \sigma_{ei}^2$

Now we need only 3N + 2 parameters--N values of a, B, and σ_{ei}^2, and $\bar{R}$ and σ_R^2. If the portfolio has many assets, the second term in (7) becomes small and if ignore it we need only 2N + 2 estimates.

I judge the single index model is less useful in a regional application than in finance, because the assumptions about covariances are harder to accept. However, some empirical investigation is warranted. In the United States, for example, the "index" for a state economy might be something like U.S. GNP or other national aggregate.

2. Problems of a Regional Application

For an individual investor, the portfolio approach is useful in several ways:

1. The covariance matrix describes important characteristics of the region's structure;

2. The normative model of Markowitz diversification provides a standard of achievement in effective diversification, independent of preferences. Consider for a moment an individual who is unwilling to articulate his preferences between risk and return. If he generates the efficiency frontier by specifying realistically the constraints on his freedom of choice, then the distance between his actual portfolio and the efficiency frontier, on Figure 1, is a useful quantitative measure of the effectiveness of diversification.

In an application to Canadian provinces, for example, St. Louis (1980) calculated the distance, in Figure 1, between its own portfolio and that point on the frontier which a province could reach with the smallest proportional change in all indutries. The measure was:

$$\sqrt{\min \sum_i (x_i - x_i^*)^2} \tag{8}$$

where x_i is the actual proportion and x_i^* is an efficient proportion.

3. If the individual does have clearly articulated preferences between risk and return, then the distance between the actual portfolio and the optimal point (tangency between the frontier and an indifference curve) is also a useful quantitative measure of achievement.

Certainly the model will have to be adapted in application to a regional government. We run into many of the general problems raised in Part I of the paper. Most of the comments made there are relevant here as well. However, some remarks particularly relevant to the application of a portfolio model to a region are the following.

Earlier in the paper, I argued that it is valid for exploratory research to think of a single decision-maker at the regional level. I would repeat that argument here and extend it to the portfolio case: it is useful to think of a single decision-maker, who maximizes expected utility of total real income received by the region's residents. He has the ability to affect the probability distributions of income from various sources; each source corresponds to an "asset" in the financial model, and the probability distribution corresponds to the probability distribution of income in that model. However, how useful the model is depends a great deal on how realistically we can model the constraints--the minimum and maximum portfolio shares referred to earlier--on the decision-maker; the constraints can reflect indivisibilities, inertia, income distribution concerns, and political compromise. Unfortunately, there seems to be little or no prior experience in formulating the constraints in a optimal portfolio model of a region.

In the financial model a purely competitive investor accepts the $\bar{r}_i$, σ_i^2, and σ_{ij} as beyond his control. He has only simple tools to shape his portfolio: he buys and sells assets in the capital markets. Many regions, especially large ones, have industries which are not price takers in their markets. Thus, regional policies can affect the parameters of the probability distributions by affecting those industries. Examples are land use planning, industrial development incentives, environmental and other regulations, labor market policies. A regional government may also be able to levy taxes with confidence they will be shifted forward or backward on to other regions. This complicates the application of portfolio analysis enormously. It may mean that early efforts in applying the model will have to be crude and limited to specifying a few points on the efficiency frontier, in the neighborhood of the region's present position.

The financial model includes only pecuniary income. A regional model should add public goods, at a minimum, and, ideally, environmental benefits. Below I suggest how public goods might be added, in a very crude fashion, but I must conclude that the environmental benefits are not likely to be included for a long time.

The income distribution or aggregation problem, referred to as a general problem in the earlier part of the paper, is not unique to analysis of diversification, but it is especially troubling here, however, because it reduces the attraction of a model the raison d'etre of which is identifying offsetting variations in different income sources. In some applications we may feel we can abstract from distribution. If not, again the solution is to specify constraints. There can be constraints to reflect the resource immobility which causes uneven distribution and constraints on government action to reflect its concerns. As in many other mathematical programming models, the shadow price of a constraint may be an especially important result of the exercise.

3. Modeling a Regional Application

In this section I describe some desirable characteristics of a portfolio model of a region. I suggest a model structure closely paralleling the financial model of a single investor. A close parallel may not be best for further empirical work, but I think it is best in an exploratory paper. The model I describe is not a full-blown model, with complete mathematical specifications. It leaves room for many different specifications. But it goes into some detail, especially on an accounting framework and on the behavior of the public sector.

I assume the region has a single decision-maker with a welfare function based on aggregate "real income", including both pecuniary and nonpecuniary elements, received by all residents in the region in a single "period" (if that period is very long, the income variable actually should be a present value of income received during the "period"). At one extreme, the decision-maker might be a central planner coordinating all investments, public and private. More likely it is a government with more limited power: it makes public investments and has some influence but not complete control over private investments. The less power the decision-maker has, the more constraints must be built into the model. Initial empirical applications may have to be to situations where the decision-maker has only a limited domain of authority--perhaps over only public assets, for example. The decision-maker's utility, however, depends on all income received by any one in the region. I assume that distribution of income is relevant, but it is reflected some how in the constraints and not in the utility function.[2]

2. I concentrate on a single region and do not explore relationships between national and regional diversification. If there is less than perfect correlation between regions, the nation can have a smaller (cont.)

The region's utility function is:

(9) $U = U(Y)$

where Y is aggregate real income. The region maximizes expected utility, and I assume its preferences are fully described by a function of the expected value and variance of the probability distribution of Y.[3]

Definition of Income

The decision-maker estimates expected values, variances, and covariances of a number of components of Y, and thus estimates the expected value and variance of total income. He attempts to trace out at least part of the efficiency frontier and to choose a point on it which is optimum according to its preferences. Ideally, income is the sum of these components:

(10) $Y = Y_S + Y_M + Y_F + Y_{TR} + (P - TX) + P' + E$

Definitions and comments are:

Y_S = property income (interest, dividends) from outside the region;

Y_M = capital income from private capital goods located in the region and owned by its residents, and wages of employees working with that capital; and also wages of regional government employees;

(note 2, cont.) variance than some regions, but the strong positive correlation between regions limits that possibility. Full integration of diversification policy into regional or multiregional decision-making models would require combining my model with the kind of normative analysis of decentralized public goods production in a Tiebout-model framework which is discussed in Stiglitz (1982) and Mieszkowski and Zodrow (1982)].

3. See discussion in footnote 1. The applicability to a regional decision-maker of the assumptions invoked there remains to be investigated. On returns, the assumption of symmetric stable distributions is questionable for employment income, especially in a small region, but less so for capital income. The nature of environmental "incidents" also argues against symmetry for the returns to environmental assets. On preferences, the pattern of risk aversion of a regional decision-maker is not something we know much about, but a portfolio model, unlike some traditional measures of diversification, does raise the issue.

Y_F = wages of employees working with capital goods located in the region but owned by outsiders (including higher governments);

Y_{TR} = transfers from higher governments to individuals, assumed exogenous to the region but obviously relevant because uncertain. Each of these components is measured after higher government taxes but before regional taxes. The sum of the four is denoted by Y'.

P = imputed value of public goods produced by regional government;

TX = regional government taxes and user charges (Y' excludes transfers within the region and TX is net of those transfers); note that P is normally greater than TX, because public goods provision produces greater imputed value than the costs of production.

P' = public goods in the region produced by higher governments; assumed exogenous to the region but relevant because uncertain;

E = imputed value of benefits from natural environmental goods and services (life support, assimilation of waste, recreation, amenity, etc.); "pollution," for example, is reduction in E because the environment is impaired.

An essential feature is that the effects of P, P', and E on residents' welfare are included in income. To be realistic, although there is economic theory on translating physical dimensions of those components into monetary equivalents [see, for example, Mishan (1982), Freeman (1979)], initial empirical applications will probably ignore P' and E and pay attention only to P in this group of three.

All these components of income are stochastic. The policymaker can affect, but only partially, every one except Y_{TR} and P' by making public investments or using fiscal policy or other policy instruments. The number of decision variables depends on the situation and on the realism of the analysis. It would seem essential to include tax base and tax rate functions and public expenditures at a minimum, but private sources of income might be made exogenous; this specification would be more relevant for a small region, or one whose firms are price takers, than for other regions.

Some of the components would best be further subdivided by industry, if regional income data permit. In the U. S., for example, the sum of Y_M and Y_F is broken down by industry, but not each one separately. It would appear best to abandon the distinction between ownership of capital in order to have a detailed disaggregation by industry.

I have not found it helpful to think of the probability distributions of income as distributions of a rate of return multiplied times a value of an "asset," for these reasons:

a. Y' includes wages. One could express the sum of wages and capital income, divided by the value of capital, as a rate of return, but that seems strained and will hinder practical acceptance of the model.

b. Y_{TR} and P' are exogenous and can't be thought of as income on capital which the region can influence. Any specification of the "capital" on which they are returns would require arbitrary units for capital.

Therefore, it is the variance-covariance matrix of levels of income, not of rates of return, which is the important description of economic structure. One would presumably want to break down regional wage income into industry components, and data and econometric models exist to do that; an industrial breakdown of capital income is much more difficult.

Existing models do not produce estimates of probability distributions of wages, and one would have to experiment with sensitivity analysis as a first step.

Estimating Means and Variances

The question arises: How does the decision-maker come by the estimates of means and variances of the probability distributions of income which he must have in order to use the portfolio approach? Presumably he will look at past history of variability in sources of income; the trick is to separate our the expected variability, for example, trend growth, from unexpected variability. However, it is an empirical task of considerable magnitude to do that, and it must be done with judgement and attention to the sensitivity of the separation to different specifications of the models that explain historical patterns. In the appendix, I sketch in detail one approach which seems to me to be defensible.

Taxes and Public Goods Production

Taxes. The regional government specifies a vector of statutory tax base functions, TB, which translate components of pecuniary income into taxable income. For example, $TB_i(\cdot)$ determines the tax base corresponding to some income source i. The TB's reflect exemptions, assessment ratios, consumption of taxable products as functions of income, etc., and so are complicated functions and not simple fractions. Some tax bases, such as property and sales and consumption of taxable products are hard to specify as functions of income components, but there are many revenue forecasting models already in existence which do this and there is also public finance literature, at least for aggregate tax bases [see Inman (1979, 1982) for a survey and empirical estimates]. (If all income of a certain kind is taxed, its TB(•) = 1.0.)

The regional government also specifies statutory tax rate functions, t'(•). Each function determines the rate on some tax base; it can be a simple constant or a more complicated nonlinear function of the base. Subscripts on t' denote the base the rate applies to. In principle, every t'(•) could be different, but in practice uniformity in taxation will make many identical. Once the government specifies TB(•) and t'(•) functions for a component of income, the resulting tax revenue is simply t'(•) times TB(•) times the income component. Thus all tax revenue is made a function ultimately of income. In this respect the model is similar to the ones in Bolton (1969), Gramlich (1969), and many regional econometric models. Tax revenue is stochastic ultimately because income is the tax base and it is stochastic.[4]

Some taxes rest immediately or ultimately on outsiders. There are two cases: 1. For taxes which are shifted on to other regions through supply and demand adjustments, TX is taxes paid by residents and is determined by the t'(•) functions, but the probability distributions of Y' reflect the shifting processes which determine before-tax income

4. One could define the probability distribution of "fiscal capacity" by estimating the distribution of tax bases and then multiplying each tax base times the national average of the t' rates on that base. This would be a useful supplement to existing estimates of fiscal capacity, which ignore uncertainty in tax bases. See Advisory Commission on Intergovernmental Relations (1982) and Calkins and Shannon (1982) for a full discussion of existing, static measures of fiscal capacity.

(full shifting raises Y' and TX by equal amounts and leaves Y unchanged); 2. For sales and excise taxes which are partially paid by tourists, the best approach is to adjust $t'(\cdot)$ downward to reflect the fact; for example, if outsiders pay the fraction v, the relevant part of $TX = t'(\cdot)(1-v)(TB(\cdot))$.[5]

Once the crucial decision functions, $t'(\cdot)$ and $TB(\cdot)$ are determined, in principle the system can be solved for to determine simultaneously the components of Y' and TX. However, this cannot be done until functions relating, P, the imputed value of public goods financed by TX, to TX (and thus ultimately to components of income). Also, grants from higher level governments must be added to give total revenue available to finance P; one can specify grants exogenously, or, in order to incorporate conditional grants and matching provisions, specify various functions relating grants to other variables. I shall not pursue the subject here but will assume below that grants have been added to TX to produce a variable, RV, total revenue available to finance public goods.

<u>Public Goods Production</u>. In this section I specify behavior in more detail, merely as an example of a specification which might be used. The technology and decision process are extremely simple. The government chooses a level of investment in a public capital good, K_p; then it always allocates a fixed proportion, b_p, of RV to fund operating costs of the production process which uses that asset. If the operating

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5. Inman (1982) used a simple linear version of the latter approach to cover both of those cases, but the one I suggest for the first case seems better, because observed data on Y' components are for income measured before taxes, and thus reflect the result of shifting.

budget must be balanced, $\sum_{p} b_p$ is constrained to equal 1.0. If the operating budget need not be balanced, there is the extremely difficult task of specifying just how responsive operating expenditures must be to government revenue. That would have to vary from region to region. (It is also quite difficult conceptually to specify the impact of interest on government debt on welfare. If we ignore income distribution, then only external debt matters, but just how negative is the effect of external interest payments is an open question.)

There is Cobb-Douglas substitutability between local labor and all other variable inputs combined, so local wages, W_p, is a constant proportion, a_p, of operating costs, and all other operating costs, C_p, is the proportion $(1-a_p)$. All of C_p is spent outside the region (this assumption is to avoid specifying the demand effects of government purchases on local industries; an alternative is to assume that the government purchases displace private purchases of exactly the same products). Then***

(14) $W_p = a_p b_p RV$

(15) $C_p = (1-a_p)b_p RV$

Each production process produces public goods with an imputed value, P_p, equal to a <u>constant multiple of the operating costs</u>:

(16) $P_p = (1 + h_p)b_p RV$

(17) $P = \sum_{p} P_p = \sum_{p} (1 + h_p)b_p RV$

Each h_p naturally depends on K_p, because the productivity of variable inputs depends on capital. Therefore, choosing K_p determines h_p and thus P_p. As with taxation, the simple constants b, h, and w could be replaced by nonlinear functions at the cost of great notational complexity which is not necessary in this paper. P is stochastic because

***Due to editing error, there are no equations numbered 11, 12, and 13 it is a function of stochastic RV (in the ideal model, P also affects E, because some public capital is environment-protecting and other is environment-deteriorating, so E is stochastic for this reason as well as for natural environmental reasons).

The specification of the public sector, understandably complex, is essential to translate uncertainty in tax bases into uncertainty in both local labor income and the value of public goods. This translation is an important determinant of the risk which regions face, and their governments' decisions must surely take it into account.

The system can be solved to determine the relationships between the government's tax functions and the variance in total real income. The $t'(\cdot)$ and $TB(\cdot)$ functions and their derivatives are crucial. The government sets them knowing the expected value and variance of private income, and absent constraints it would use them to help stabilize Y. But constraints, such as a prohibition against debt financing for current operations, may force the local government to be destabilizing.

It is illuminating to note that P can be seen as the sum of three components:

(18) $P = \sum_p W_p + \sum_p C_p + \sum_p r_p K_p$, where the first two are variable costs and $\sum_p r_p K_p$ is the residual (nonpecuniary) return on total public capital. Here is a case where it <u>is</u> useful to think of a rate of return. Once K_p is determined, we have

$$\text{(19)}\quad \begin{aligned} \sum_p r_p K_p &= \sum_p P_p - (\sum_p W_p + \sum_p C_p) \\ &= \sum_p (1 + h_p) b_p RV - \sum_p b_p RV \\ &= (\sum_p h_p b_p) RV \end{aligned}$$

and the average <u>rate</u> of return on all public capital is

$$\text{(20)}\quad \sum_p r_p K_p / \sum_p K_p = (\sum_p h_p b_p) RV / \sum_p K_p$$

Very simply, the public sector commits capital to "overhead" and then has to accept a stochastic return on its fixed capital.

The Regional Variance-Covariance Matrix

In the earlier description of the financial model for a household, the variance-covariance matrix was the essential description of the "structure" of a portfolio. A similar matrix is the essential description of the structure of the regional economy and tax base. However, the covariances are of levels of income, not rates of return, so the matrix does not have the x weights.

There are seven components of income in (10). For ease of notation and discussion, I denote Y_S, Y_M, Y_F, Y_{TR}, (P-TX), P', and E by the letters S, M, F, TR, P, P', and E, respectively. The matrix is:

$$
(21) \qquad
\begin{matrix}
\sigma_S^2 & \sigma_{SM} & \sigma_{SF} & \sigma_{STR} & \sigma_{SP} & \sigma_{SP'} & \sigma_{SE} \\
\sigma_{MS} & \sigma_M^2 & \sigma_{MF} & \sigma_{MTR} & \sigma_{MP} & \sigma_{MP'} & \sigma_{ME} \\
\sigma_{FS} & \sigma_{FM} & \sigma_F^2 & \sigma_{FTR} & \sigma_{FP} & \sigma_{FP'} & \sigma_{FE} \\
\sigma_{TRS} & \sigma_{TRM} & \sigma_{TRF} & \sigma_{TR}^2 & \sigma_{TRP} & \sigma_{TRP'} & \sigma_{TRE} \\
\sigma_{PS} & \sigma_{PM} & \sigma_{PF} & \sigma_{PTR} & \sigma_P^2 & \sigma_{PP'} & \sigma_{PE} \\
\sigma_{P'S} & \sigma_{P'M} & \sigma_{P'F} & \sigma_{P'TR} & \sigma_{P'P} & \sigma_{P'}^2 & \sigma_{P'E} \\
\sigma_{ES} & \sigma_{EM} & \sigma_{EF} & \sigma_{ETR} & \sigma_{EP} & \sigma_{EP'} & \sigma_E^2
\end{matrix}
$$

However, as suggested above, we would probably combine Y_M and Y_F, but then disaggregate the total by industry. The matrix describes the risk to the region after it has chosen all its decision variables; it makes its choices with an eye to their effect on the matrix.

It is helpful to summarize characteristics of each row, for some typical regions. In comparing regions, one needs to standardize roughly for size, so I refer to the absolute value of each term as "large" or "small" relative to the variance in total income Y. The following discussion is most applicable to regions in the United States.

--S is property income, and it has a low variance because it includes interest and dividends. (If we include undistributed profits or capital gains or losses, the variance will be higher). Its stability is an important factor in higher income regions and retirement areas which depend more heavily on S than do other regions. Going on in the S row, we expect σ_{SM} to be positive. M is capital income and wages from private assets, and in the business cycle the <u>typical</u> region moves with the rest of the nation, from which much of S is derived. But σ_{SM} is probably small. The cycle is not the only source of risk, the region's industries don't exactly duplicate the nation's anyway, and dividends and interest are stable. A farming or mining region might have M very independent of the national economy, so have nearly zero σ_{SM}.

--The σ_{SF} is similar to σ_{SM}, because M and F are highly positively correlated; σ_{STR} is probably small but negative, because of automatic stabilizing transfers in the national economy; σ_{SP} is positive because the regional tax base includes S, but is probably small for the same reasons as σ_{SM} is small; σ_{SE} should be very small, as there is no reason to expect high <u>outside</u> property income to go along with a high quality of the environment in the region.

--In the M row, σ_M^2 depends on the economic structure, but for most regions it is large. The covariance between M and F is of course positive and large, because for the most part locally owned firms and outsider-owned ones move together. The fact that F includes only wages while M includes both profits and wages mitigates that a bit. The σ_{MTR}

is of course significantly negative because of national government unemployment insurance and other stabilizing transfers; σ_{MP} is positive and fairly large in most regions in which locally produced income is the major part of the tax base (a region dominated by retired people living mainly on S is an exception), and because local government wages are included in M; $\sigma_{MP'}$ probably is near zero, except in those few cases where higher government's reduction of P' is the cause of a recession which reduces M; σ_{ME} probably is negative, because the greater is production in the region the more likely the environment is to deteriorate. This negative covariance is some small comfort to a region suffering from reduced M.

--In the F row, there are high positive covariances with M and P, but a high negative one with TR and also a negative one with E. The covariances with S and P' are near zero.

--TR of course offers significant stabilizing influences because it moves opposite to M, F, and to some extent to P as well. TR and P' are both results of higher government budgetary policy, and it is hard to generalize. The σ_{TRE} probably is positive, because M and F are negatively correlated with E.

--The P row shows generally positive covariances, except σ_{PE}, and they are significant forces for instability. We saw examples of public sector reinforcements of private sector shocks in many regions in the 1970's and we saw them again in the recent recession.

--In the E row, we expect stability elements in the general independence between E and S and between E and P', and in the negative covariance with M, P, and F. Note that investment in K_p can increase the ability of the natural environment to produce E, but after the decision is made on K_p the covariance is negative because economic activity tends to increase TX and thus P, but to reduce E.

All in all, a very intuitive survey of the very aggregated matrix suggests a stabilizing role for TR and E, and, to a lesser extent, for S, and a very destabilizing role for M and P and F. These conclusions are hardly surprising, but they show the use of the covariance matrix in organizing descriptions and predictions of the forces creating risk for the region.

The matrix suggests some preliminary testable, but not tested, empirical hypotheses. For example:

--a high income region will have more S than a lower income one, and the stability of S will lead it to take more risks in its industrial structure (affecting M and P). That would show up in more aggressive industrial development efforts to attract high income but unstable industries. The region will also rely more heavily on wages and sales taxes which are less stable than some other taxes.

--a region with a large retired population will have similar incentives, even if its average income is not high.

--A region which prefers a large expected value of the public sector will seek to reduce the instability which may accompany large size, by seeking a stable industrial base (M and F) and tax base. If its historical heritage of M and F is very unstable, it will seek a stable tax base more vigorously, even at the expense of other public sector goals such as static efficiency and equity.

<u>Evaluation of a Potential New Asset</u>

For many regions, some crucial planning decisions are those encouraging or discouraging single large changes in the economy, such as a major public works project or a major new industrial investment. Regional benefit-cost analysis is used to evaluate proposed new assets in the regional portfolio such as industrial plants, public works, and environment-augmenting public assets. Refined methods have been developed to measure the change in regional real income under certainty, and, more recently, the expected value of an uncertain change. Major examples are analyses of industrial plants, in which the analyst balances expected values of damages from recurring pollution, or occasional oil or waste "spills," against expected money income.

The portfolio variance approach is valuable in such benefit-cost analyses. So far, however, we have seldom used it. Even when we recognize uncertainty, in current practice we confine ourselves to determining whether the <u>expected value</u> of net benefits from the new asset is positive. For example, in evaluating industrial development or a transportation facility, we allow for uncertain demand, but we consider only the expected value of benefits, not the variance or covariances with assets already in the region. Even if we get a sense of the variance by doing sensitivity analysis, we don't consider covariances explicitly. And in evaluating petroleum or hazardous waste facilities, we look at probabilities of spills and compute the expected value of environmental damages, and we may even consider the variance, but we don't consider covariances with other activities.

In some cases such an analysis may be very incomplete. For example, Stokes (1982) analyzed the effects of oil transport and refining facilities to be located on Puget Sound in the state of Washington in the U.S. He compared estimates of expected value of spill damages to estimates of regional income, which he assumed to be certain. He ignored variances and covariances, even though one assumes the facilities would have a significant effect on the income of small regions on Puget Sound and would have a risk-reducing effect from negative covariances between environmental quality and local income and tax revenue.

The portfolio approach should be used in such cases. Even a crude and incomplete specification of the parameters will be helpful (for an extensive discussion of the evaluation of a potential new asset, emphasizing the role of constraints on sizes of existing assets when the new asset appears, see Bolton (1982). The applicability of the approach in this rather narrow context is only one example of its applicability to analyses of regional economic structure.

CONCLUSION

Surely we need much more theoretical and empirical work to exploit the portfolio variance approach fully. But I believe it has great value. I have suggested some extensions of the concept developed by previous authors, and have sketched out possible approaches in building a model of a region making portfolio decisions. An expanded approach will build on recent work in regional modeling and regional benefit-cost analysis, and also on established theories of public finance. The portfolio model leads the researcher and policy analyst to ask different questions from earlier approaches to diversification, and to seek out different regional models and data. I hope this exploratory paper will stimulate more work that is needed.

APPENDIX

OUTLINE OF EMPIRICAL APPROACH

The empirical approach is to estimate the riskiness of various sources of income in a region by the variability of deviations from trend in some historical period. This appendix applies only to pecuniary earnings from employment, and also government transfer payments, but does not go into the incorporation of public goods into the model. (Earnings data may include net income of proprietors; in the U.S.A., for example, they do.)

I. ASSUMPTIONS AND DEFINITIONS. A region is considered to have "assets" in year 0 and to make investments that earn "returns" in year 1. Each "asset" is employment in some industry, and the "returns" are the constant dollar value of earnings in that industry. In this outline, it will be assumed for simplicity of exposition that only the single-year year 1 returns are relevant, but with some modifications the approach also can be used to describe a situation in which the present value of future returns, in 1 and succeeding years, is of concern to the decision-maker.

Let Y_{i0} and Y_{i1} = earnings in industry i in years 0 and 1, respectively.

The value of Y_{i1} is uncertain and is not known to the decision-maker. However, he knows the probability distribution of Y_{i1}. Every possible value of Y_{i1} can be described by:

(1) $$Y_{i1} = Y_{i0}(1 + g_i)$$

where: Y_{i1} = random level of earnings in year 1

Y_{i0} = level of Y_i in year 0. This number is known with certainty and is not a random variable.

g_i = a random growth rate of Y_i between year 0 and year 1.

Note that the growth rate g_i is not known to the decision-maker, but its probability distribution can be estimated from historical data on year-to-year growth rates as described below. From (1) it is clear that the probability distribution of Y_{i1} is a simple function of the probability distribution of g_i, so that g_i is the random variable of fundamental importance. (As g_i is always the growth rate between year 0 and year 1, the year subscript is suppressed for simplicity of notation.)

The random variable g_i can be expressed as the product of the expected value of its probability distribution and a relative deviation from the expected value:

$$(2) \qquad 1 + g_i = (1 + \bar{g}_i)(1 + u_{i1})$$

where: $\bar{g}_i$ = expected rate of growth between 0 and 1; it is the expected value of the probability distribution of growth rates

u_{i1} = random deviation from the expected growth rate, expressed as a deviation relative to $(1 + \bar{g}_i)$; the expected value of u, $E(u_{i1})$, is zero; the variance is denoted by σ_{ui}^2; u and g are uncorrelated.

Combining (1) and (2), we have an expression for the random variable, Y_{i1}:

$$(3) \qquad Y_{i1} = Y_{i0}(1 + \bar{g}_i)(1 + u_{i1})$$

In this analysis, the number that is analagous to r_i, the rate of return in portfolio theory, is $Y_{i1}/Y_{i0} = (1 + g_i)$, or one plus the rate of growth. Adopting the portfolio theory notation, we then have:

$$(4) \qquad \bar{r}_i = E(1 + g_i) = (1 + \bar{g}_i)$$

$$(5) \qquad \sigma_i^2 = \text{the variance of } (1 + g_i) = (1 + \bar{g}_i)^2 \sigma_{ui}^2 \qquad \text{(from (2))}$$

$$(6) \qquad \sigma_{ij} = \text{the covariance between } (1 + g_i) \text{ and } (1 + g_j)$$

$$= (1 + \bar{g}_i)(1 + \bar{g}_j)\,\sigma_{uiuj} \qquad \text{(also from (2))}$$

If the decision-maker can make acceptable estimates of all the variances and covariances, he can use the Markowitz portfolio balancing analysis. The next section outlines how these estimates can be made from historical data on the earnings in each regional industry.

II. ESTIMATION OF EXPECTED GROWTH RATES, VARIANCES, AND COVARIANCES FROM HISTORICAL DATA

I assume that a decision-maker can make useful first-cut estimates of the expected growth rates, variances, and covariances from historical annual time series on Y_i, if they are available from the statistical authorities of the country (in the U.S.A., such data are published by the Bureau of Economic Analysis, U.S. Department of Commerce). One needs to examine the validity of this assumption carefully, of course, taking into account both data quality and econometric issues. The decision-maker may well want to adjust some of the estimates from historical data to reflect his *a priori* judgment, changes in structure since the historical period, and weaknesses in the data.

In my own preliminary empirical analysis, I have used time series from 1970-1982 for employment earnings by industry in each of a number of states in the U.S. economy. These data are published by the Bureau of Economic Analysis in machine-readable form and are summarized every year in the August issue of the Bureau's statistical periodical, *Survey of Current Business*.

This section describes five different methods of estimating the parameters, in order to give a notion of the range of choices open to the decision-maker making such estimates. (I have experimented with all five, but will abandon some on the basis of sensitivity of results to the method.) In all five cases, the decision-maker is assumed to think of historical movements of Y_i as being determined by a relatively simple model:

$$(7) \qquad Y_{it} = \hat{Y}_{it}(1 + u_{it})$$

where: Y_{it} = value of Y_i in year t
$\hat{Y}_{it}$ = the secular trend value of Y_i
u_{it} = the relative deviation from the trend in year t

The expected growth rate ($\bar{g}$ in Section II) is estimated as the growth of the secular trend, that is, the growth rate of $\hat{Y}_i$. The deviations from trend in the historical series are used as the estimates of u as defined in Section I.

It is useful to suppress the i subscript; from now on it is understood that all equations apply to some particular industry. Rewriting (7):

$$(8) \qquad Y_t = \hat{Y}_t(1 + u_t)$$

In each of the five methods, a trend equation is fitted to the historical time series for the industry. The five methods differ from each other in the method of estimating the secular trend. The estimate of $\bar{r}_i = (1 + \bar{g})$ is the value of $\hat{Y}_1/\hat{Y}_0$, so that $\bar{g}$ is the <u>rate of growth along the trend line</u>. It is not the actual growth between year -1 and 0 in the industry and region in question. It would not be appropriate to use the actual growth rate, because years -1 and 0 will have been ones subject to peculiar random influences. (In the U.S.A., for example, constant dollar earnings <u>declined</u> between 1981 and 1982 in most industries in most states, because 1982 was a serious recession year. If one used the actual growth rate between 1981 and 1982, it would imply that decision-makers expected negative "returns" in most industries.)

After the trend equation is calculated, the absolute deviation from trend, $e_t = Y_t - \hat{Y}_t$, and the relative deviation, $u_t = e_t/\hat{Y}_t$, are calculated for each year in the historical period. There is thus an observation of u for each year of the historical period. The variance of those observations (corrected for degrees of freedom) is thus the estimate of σ_i^2 referred to in Section I, and, for any two industries, i and j, the covariance of the u_i and u_j series is the estimate of σ_{ij} referred to in Section II.

The next section describes each of the five different methods.

III. FIVE DIFFERENT METHODS OF ESTIMATING THE TREND

This section describes the different methods of estimating the trend values, $\hat{Y}$. Remember that in each method, after estimating the $\hat{Y}$'s, the series of u's is estimated as described in the previous section. All five of these methods specify a relatively simple model of the historical time period. In practice, a regional decision-maker might want to specify a fairly complex econometric model and then calculate the variance of the deviations of actual earnings from the time path predicted by that model. On the other hand, an independent analyst, who is interested in studying the industrial structures of a large number of regions, and in doing so at a fairly fine level of industrial detail, may have to confine himself to relatively simple forms because he will be applying the form to hundreds of different industries. I am assuming the latter situation here.

1. Trend Model 1. Simple Constant Growth Trend. In this model, the trend in industry earnings is one of a constant rate of growth, $Y_t = Y_o(1 + g')^t$, so that:

$$Y_t = \hat{Y}_o(1 + g')^t(1 + u_t) \tag{9}$$

Y_o is the trend level in the base period (Y_o is not to be confused with Y_0). The trend is estimated by least-squares regression on logarithms:

$$\ln \hat{Y}_t = \ln \hat{Y}_o + t[\ln(1 + g')] \tag{10}$$

The least-squares estimate of g' is used as the estimate of $\bar{g}$ referred to in Section I.

2. Trend Model 2. Simple Constant Growth Trend with autoregressive Deviations from Trend. In this model, the trend is the same in Model 1, but the deviations from that trend follow an autoregressive pattern:

$$(1 + u_t) = (1 + u_{t-1})^{\rho}(1 + u'_t) \tag{11}$$

where u' is a random variable with zero mean and is not autocorrelated. Then,

$$Y_t = \hat{Y}_o(1 + g')^t(1 + u_{t-1})^{\rho}(1 + u'_t) \tag{12}$$

Again, the estimate of g' is used as the estimate of $\bar{g}$. The series of u', not the u, is used as the estimate of the relative deviation u referred to in Section II. Estimates of the u' are obtained by the Cochrane-Orcutt two-step process: first, estimating (10) by least squares on logarithms; second, estimating a new set of deviations from the equation by a Cochrane-Orcutt transformation.

3. Trend Model 3. Varying Growth Trend. The trend is of the form $\hat{Y}_t = b_1 + b_2Y_{t-1}$, and:

$$Y_t = b_1 + b_2Y_{t-1} + u_t \tag{13}$$

Note that along the predicted year to year growth rate is not constant:

$$1 + g'_t = \hat{Y}_t/Y_{t-1} = b_1/Y_{t-1} + b_2 \tag{14}$$

Here g' has a subscript t to denote that the trend growth rate changes from year to year. If the trend is growing steadily, then $\hat{Y}_t > Y_{t-1}$; if b_1 is positive, the growth rate is initially greater than b_2 but falls steadily toward b_2; if b_1 is negative the growth rate is initially below b_2 but rises steadily toward b_2.

The parameters b_1 and b_2 are estimated by least-squares regression. Because the trend growth rate is not constant, there is no obvious choice for the estimate of $\bar{g}$, the expected growth rate for the portfolio model. One possibility is to estimate $\bar{g}$ as the rate between the actual in year 0 and the predicted for year 1:

$$1 + \bar{g} = b_1/\hat{Y}_0 + b_2 \tag{15}$$

4. Trend Model 4. Varying Growth Trend with Autogressive Deviation from Trend. Here, the trend is as in Model 3, but the error, u_t, in (13) is assumed to follow an autogressive pattern, $u_t = \rho u_{t-1} + u'_t$, so that:

$$Y_t = b_1 + b_2Y_{t-1} + \rho u_{t-1} + u'_t \tag{16}$$

As in Model 2, the estimates of u' are used as the deviation series rather than u itself, and they are made by the same Cochrane-Orcutt two-step process described for Model 2.

5. Trend Model 5. Rolling Growth Rate Model. In this case, the trend value for each year t is estimated by assuming that rate of growth over the previous year is the same as was the average annual rate of growth over the previous <u>four</u> years. Thus:

$$Y_t = Y_{t-1}(1 + g'_t)(1 + u_t) \tag{17}$$

where g' is the average annual growth rate between year t-5 and year t-1. Note that this is the only one of the five methods in which the growth trend is not estimated by a regression equation. Rather the trend is updated each year based on the growth in the previous four years; then the deviations e and u are calculated as described in Section II. As in Models 3 and 4, the trend growth rate is not constant, so there is no obvious choice as the estimate of the expected growth rate. One must be careful not to use a four year period ending in a cyclical peak or trough.

Because this is not a regression method, it turns out that the observations of u do not necessarily average out to zero; in other words, the trend values may be predominately above or below the actual values. To correct for this, the estimate of $1 + g$ is $(1 + g')(1 + \bar{u})$, where $\bar{u}$ is the average of the observed values of u.

IV. INSPECTION OF VARIANCE-COVARIANCE MATRICES

The work described in Section III produces an estimate of the expected growth rate and a series of estimated u values for each of the n industries in a region. In the next step, the full set of n variances and the $n^2 - n$ covariances can be inspected for interesting patterns. (In my own work, I've not yet done this systemtatically for any state, but a preliminary inspection of the matrix for Massachusetts do confirm that there <u>are</u> interesting patterns. A particular industry may be highly positively correlated with some other industries, but hardly correlated at all with still other industries. It is interesting to see that many pairs of industries are essentially uncorrelated, even though much of regional theory (base multiplier theory, input-output theory, etc.) would suggest that most industries move along together. That is certainly true for general trends, but when it comes to deviations from trend, which of course are all that are considered when decision-makers are focusing on unexpected movements, then many industries move quite independently of one another.

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Government transfer payments, which if data permit, can be analyzed as a separate income source. One would expect them to be generally negatively correlated with earnings in most industries, because transfers include unemployment insurance payments and general welfare assistance payments. One interesting result of this step is to determine how strong these correlations are in a region, in other words how effective transfers are as automatic stabilizing sources of income.

V. PORTFOLIO MEASURES OF DIVERSIFICATION

In this step the optimum diversification patterns can be determined for a region, by generating an efficiency frontier. If this is done for two or ore regions, one can compare the regions in terms of how distant from the frontier they are. Another way to put this is to say that the exercise can determine if there is some other combination of industries (determined within practical constraints on a region's ability to attract or rid itself of industries)) which would have the same expected growth rate but lower risk, or, which would have the same risk but a higher expected growth rate.

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DISCUSSIONS*

Paper by A. Kochetkov

Discussion participants, in chronological order: P. Joynt, R. Bolton, U. Loeser, R. Kulikowski, A. Straszak, L. Kajriukstis, A. Kochetkov.

Questions raised concerned the kinds of models implied in the paper, ways of compensation for regional company activities, the leading mechanism of these activities and the course of the IIASA project considered.

With regard to models two types were said to be distinguished, namely conceptual and quantified models. Compensation was said to be made out of a special fund, not excluding a form of subsidy. Other potential compensation mechanisms were pointed out: economic, organizational or legal.

As far as driving forces are concerned - both planning and market should be accounted for in a due harmony, notwithstanding difficulties in its attainment. This harmony should extend further to such fields of development as economic, social and environmental.

The course of the IIASA project was said to contain a number of future meetings and a closure in 1986, after major directions of work would have been exploved.

Paper by R. Bolton

Discussion participants: K. Polenske, S. Dresch, D. Boekemann, G. Bianchi, R. Bolton.

At the beginning discussion centred around the shape of indifference curves and the riskwise attitudes, which was explained by referring to assumptions made in the paper. This discussion, however, led to other, more general questions, related to modelling of utility in cases when income does not account for all of it and when political considerations enter the scene.

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* as indicated, for the sake of shortness and clarity discussions shall be presented in summarized form (eds.).

The paper, of course, does not consider these questions, but the approach can be extended to encompass some additional aspects, e.g. in the case of distinct multi-subregional planning, through treatment of each subregion as an asset in a national portfolio.

Paper by R. Espejo

Discussion perticipants: A. Kochetkov, S. Dresch, G. Bianchi, U. Loeser, R. Espejo.
Discussion focussed on the rules of application of the recursive scheme and its details. References were made to works by S. Beer and by R. Espejo, where deployment of the scheme is shown in more detail. Discussion participants have shown interest in the software developed and in its practical applications. One such application, other than described in the paper, was roughly outlined.

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