A Portfolio Analysis of Manufacturing within the U.S. Urban System

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There has recently been a restructuring of manufacturing activity within the American space-economy. The traditional manufacturing belt of the U.S. has lost employment, while manufacturing growth has occurred in the Sunbelt region. However, neoclassical growth theory only partially explains this spatial economic shift. A dualism of capital-intensive and labor-intensive industries in the Sunbelt and multidirectional corporate control among regions suggests that an alternative framework is needed to explain this geographic industrial diversification. This article employs portfolio theory as its framework because many corporations seek to reduce production risk through management of an investment portfolio. A spatial analysis of urban manufacturing areas for the business cycle 1971-1976 suggests that although the industrial heartland is currently in decline, urban areas within this region are part of an efficient geographical portfolio. For firms that choose a risk aversion strategy, the current outflow may become more stable when risk reaches an equilibrium.

At one time, the continued existence of the geographical concentration of American manufacturing in northeastern and north central states was a widely-accepted proposition. It was even suggested that relative manufacturing growth had achieved interregional equilibrium (Cohen and Berry, 1975). More recently, the large declines in absolute employment in the heartland manufacturing sector has led research suggesting that fundamental realignment is taking place in U.S. economic geography, with dissolution proceeding in the core and growth taking place on the periphery of the South and West (Chinitz, 1978; Hansen, 1979; Hekman, 1982; Norton and Rees, 1979). Much of this work discusses a geographical division of labor and ultimately relies on a product/regional lifecycle interpretation of

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regional economic change. Other research points to the geographical rationalization of corporate activity and the relationship between the control structures of corporations and geographical space (Clark, 1981; Dicken, 1976; Scott, 1982).

However, other evidence exists that suggests that such national decentralization may partly comply with a portfolio process. For example, Casetti (1981) has shown that manufacturing growth in the American Sunbelt is more a function of capital deepening than of the increasing labor intensity suggested by neoclassical theory. Suarez-Villa (1983), in an examination of the same region, found a strong element of dualism; both capital-intensive and labor-intensive industries existed in a region of presumed labor abundance. In addition, Dicken (1976) has shown that the flow of control in American industrial enterprise is not unidirectional. This researcher found that while 1,541 California firms were being acquired by out-of-state enterprises, California enterprises acquired 1,030 out-of-state firms. These examples are symptomatic of a geographical diversification of industry in America that conforms to portfolio processes.

This article analyzes the interregional structure of the American space economy from the perspective of portfolio theory. Although industrial heartland cities such as Detroit and Gary are currently in a decline, urban sites within this region comprise important elements of efficient geographical portfolios. In a portfolio context, therefore, these places can be expected to be both importers and exporters of investment capital, as long as the American space economy is not perfectly integrated. The basic assumption behind this application of the theory is that individual regions can be suitably considered "assets" of a multiregional, national portfolio, with each region contributing both "return" and "risk" characteristics to the national space economy.

According to portfolio theory assumptions, firms consider the interrelationships among regions over a business cycle as well as the absolute performance of any single region. The assets (regions) used in this paper consist of the set of large manufacturing SMSAs of the U.S. during the period 1971-1976. The next section of this article describes the portfolio-theoretic approach to interregional relationships; the succeeding section consists of the operational portfolio model and a description of the data used in the analyses. The next section describes the efficient portfolio of American manufacturing SMSAs, and a selection of efficient city-biased portfolios. The article concludes with a discussion of the implications of portfolio analysis for interregional processes.

Portfolio Analysis in an Interregional Context

The American space economy is not perfectly integrated along regional lines so that geographical diversification of a firm can, if all other things remain equal, lead to increased stability of production. Several reasons have been proposed for a firm's geographical diversification. Erickson (1976) has placed geographical diversification of the firm within a product lifecycle context, while Schmenner (1980) simply notes the technological problems of on-site expansion. Clark (1981) presents a hypothetical diversification case based on the "employment relation," and Moriarty (1983) has described more conventional labor considerations for spatial diversification. Efforts to decrease production risk (i.e., variability) also can be considered a potential reason for such diversification.

A major tenet of financial-economic theory is that an efficient asset portfolio either minimizes risk for an expected return or maximizes return for a given level of risk. Assets are considered in terms of their relationship to all other potential assets of the portfolio. The risk-return relationship of a portfolio can be assessed by a mean-variance model which defines the expected return as follows (Markowitz, 1959):

$$(1): \quad E(P) = \sum_{i=1}^{n} X_i \, E(X_i),$$

where $E(P)$ is the expected mean return on portfolio P;
x_i is the amount invested in the *i*th asset; and,
$E(X_i)$ is the expected return on the *i*th asset.

The risk associated with the portfolio is measured as the variance of its return:

$$(2): \quad \sigma^2(P) = \sum_{i=1}^{n} \sum_{j=1}^{n} X_i X_j \sigma^2_{ij},$$

where $\sigma^2(P)$ is the expected risk of portfolio P;
and σ^2_{ij} is the covariance between the *i*th and *j*th assets.

Portfolio risk is not determined by the sum of the risks of individual assets but is calculated as the sum of the covariances of paired returns. Because risk in the mean-variance model is measured by the covariance between pairwise assets, such risk can be reduced by designing an allocation of assets that minimizes total covariance for a targeted return. An efficiently diversified portfolio, in the absence of risk-free investment, is likely to consist of assets with minimal covariances.

The portfolio theory's diversification emphasis has led to the use of portfolio models in two areas of spatial economic analysis: regional industrial diversification analysis and a micro-level analysis that concerns the geographical diversification of the firm. Conroy (1975) was the first to consider a region's industrial employment structure as a portfolio of assets. Barth et al. (1975) suggested a regional policy role for portfolio analytic techniques. Recent applications of such theory include St. Louis' (1980) evaluation of employment diversification in the Canadian provinces, and Bolton's (1984) solutions to many of the conceptual problems of considering only employment in the asset composition of a region's economic portfolio. The growing body of regional diversification literature using portfolio analytic methodology indicates that this approach holds promise for future research.

Micro-level portfolio analysis has primarily been used in the study of multinational firms and foreign direct investments (Cromley and Hanink, 1985; Miller and Pras, 1980; Rugman, 1979; Senbet, 1979). Portfolio-theoretic micro analysis at the intranational level remains largely undeveloped. Wahlroos (1981) used a portfolio model to derive benefits to the firm from multiplant operation; this research demonstrated that the larger the number of plants operated by the firm, the smaller the variance of profits or risk. Hanink (1984) provided applications of a zero-one quadratic portfolio model to multiplant location considerations that included intra-firm rationalization and merger.

The Operational Model

The data set employed in this analysis consists of the annual values of manufactured shipments per employee over the period 1971-1976 for large American SMSAs (see Table 1). These values were transformed into constant 1972 U.S. dollars by using GNP deflators. Shipment value was used as the economic indicator because it measures output, and standardizing this measure on a per-employee basis eliminates effects of SMSA size. The period of 1971-1976 was selected as a representative national business cycle: it includes the 1971–1972 upswing, 1975 downswing, and 1975 upswing. The data do not account for individual SMSA industrial structures, but are purely geographical aggregates. Despite these limitations, the data are sufficient for the purpose given.

In the mean-variance model, the efficient diversification of production can be determined either by maximizing return, given a fixed level of risk, or minimizing risk, given a desired return level. Because the latter exercise involves a linear constraint set, the mean-variance model is solved as the following quadratic program:

(3) Minimize $\sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_j^2 X_i X_j$

(4) such that: $\sum_{i=1}^{n} X_i E(X_i) = \bar{E};$

(5) and: $\sum_{i=1}^{n} X_i = 1$

where σ_{ij}^2 is the covariance in value of shipment per employee between the *i*th and *j*th SMSA;
X_i is the proportion of the total budget invested in the *i*th SMSA;
$E(X_i)$ is the expected value of shipment per employee level in the *i*th SMSA, and
$\bar{E}$ is the desired level of expected shipment value.

The objective function (equation 3) ensures that the total covariance (i.e., risk) of the optimal portfolio is minimized given equation (4), requiring a fixed level of return. Equation (5) is a constraint requiring that the total budget (some established level) is invested in some SMSA. The Lagrangian function for this program is written as follows:

(6) $L(X,\lambda) = \sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_j^2 X_i X_j + \lambda_1(E - \sum_{i=1}^{n} X_i E(X_i) + \lambda_2(1 - \sum_{i=1}^{n} X_i)$

At optimality, the Kuhn-Tucker necessary conditions require that:

(7) $-2 \sum_{i=1}^{n} \sigma_{ij}^2 X_i^* + \lambda_1^* + \lambda_2^* \geq O$

(8) $\sum_{i=1}^{n} X_i^* E(X_i^*) = E$

(9) $\sum_{i=1}^{n} X_i^* = 1$

where X_i^* is the optimum level of investment in the *i*th SMSA,

λ_1^* is the optimum lagrangian associated with equation (4), and

λ_2^* is the optimum lagrangian associated with equation (5).

The lagrangian λ^*_1 is interpreted as $\partial\sigma^2(P)/\partial E(P)$, the rate of change in the minimum risk given an incremental change in expected return, while λ^*_2 is interpreted as $\partial\sigma^2(P)/\partial b$, the rate of change in the minimum risk given an incremental change in the budget level (b) (Wilkes, 1977). For any $X_i^* > 0$, equation (7) must be strictly equal to zero; otherwise, if $X_i^* = 0$, equation (7) must be greater than or equal to zero. The above mean-variance formulation is solved by a modified simplex algorithm that only permits X_i to be a basic feasible variable (part of the portfolio) if its corresponding slack variable in equation (7) is non-basic (Cooper and Steinberg, 1970).

The absolute risk-minimizing geographical portfolio in the absence of a desired return can be found by relaxing equation (4). In this case, E_{min} is the rate of return associated with the risk-minimizing solution. The efficient

Table 1.
Mean ($\bar{X}$) And Standard Deviation Of Value Of Shipments Per Employee, 1971-76: By SMSA

SMSA	$\bar{X}$	S	SMSA	$\bar{X}$	S
AKRON	35135	2675	MEMPHIS	54615	5398
BALTIMORE	44253	3577	MIAMI	27737	802
BIRMINGHAM	42850	5752	MILWAUKEE	38547	3776
BOSTON	33576	1585	NEW ORLEANS	52756	11044
BRIDGEPORT	32017	892	NEW YORK	33233	1644
BUFFALO	46759	4441	NEWARK	41089	3867
CANTON	43815	4801	PEORIA	50875	7288
CHATTANOOGA	39520	3081	PHILADELPHIA	41965	3825
CHICAGO	41057	3095	PHOENIX	36736	2551
CINCINNATI	45970	3640	PITTSBURGH	40874	5033
CLEVELAND	38682	1974	PORTLAND	41895	3720
COLUMBUS	38661	3209	PROVIDENCE	28766	1919
DALLAS	38145	2210	READING	33329	2052
DAVENPORT	51749	6369	RICHMOND	50300	6154
DAYTON	34999	2685	RIVERSIDE	40149	3474
DENVER	43180	2735	SAN DIEGO	32829	2256
DETROIT	53710	2771	SAN FRANCISCO	55713	7099
ERIE	33677	1815	SAN JOSE	39853	1824
GARY	72809	19089	SEATTLE	47640	2249
GRAND RAPIDS	37924	1612	SPRINGFIELD	34571	1700
GREENSBORO	38758	1709	ST. LOUIS	49327	5467
HARTFORD	31938	3337	SYRACUSE	42871	5260
HOUSTON	75650	14924	WASHINGTON	34415	1285
INDIANAPOLIS	39294	2735	WICHITA	50871	4922
JERSEY CITY	44758	4301	WILMINGTON	50819	3273
KANSAS CITY	60525	3535	WORCESTER	31468	3529
LANCASTER	38341	2892	YORK	32664	2061
LOS ANGELES	41099	3415	YOUNGSTOWN	45625	4061
LOUISVILLE	60262	3884			

Note: 1972 dollars

portfolio having the highest expected return, E_{max}, can be found by identifying the SMSA having the greatest shipment value. The return maximizing and the risk minimizing portfolios represent only the extremes of a frontier of efficient portfolios. In the case of N securities, this set of efficient portfolios can be represented or described in terms of a small set of corner portfolios that mark rate of return levels where there is a change of securities in the portfolio (Sharpe, 1963). These corner portfolios can be determined by solving the quadratic formulation as a parametric program where the rate of return is perturbated. In certain finite intervals, then, the basic variables will remain constant, resulting in the same discrete portfolio of SMSAs although in a different linear combination. At critical return values, E_c, basic and non-basic variables are interchanged to prevent unfeasible solutions. These critical return values are determined by the parametric portfolio program. Over each finite interval, risk will increase as a quadratic function of rate of return; this risk-return relationship permits manufacturers to use a range of investment strategies, from strict risk aversion to full risk-taking.

The model is applied to the development of two kinds of location portfolios. The first application is to the entire set of SMSAs with no allocational constraints. An efficient frontier, which defines optimal portfolio composition for different levels of return (i.e., mean values of shipments per employee), is generated for a hypothetical firm that has no current locational ties. The other application of the model concerns the generation of efficient frontiers for a set of SMSA-biased portfolios. In these cases, hypothetical firms are assumed to have existing fixed production, on a proportional basis, in a particular SMSA.

Three assumptions are made in the application of the model. First, it is assumed that the hypothetical firm is a utility maximizer, not a profit maximizer as in the neoclassical case. The generalized utility function consists of both a return-maximizing goal and a risk-minimizing goal. This type of utility function is consistent with firm objectives under uncertainty (Miller and Romeo, 1979). Second, it is assumed that all SMSAs under consideration for the portfolios meet minimum requirements as potential locations for investment by the hypothetical firm. Factor cost variability and market proximity are ignored; the viability of a location depends solely on its contribution to the firm's geographical portfolio. Third, it is assumed that risk and return, as defined here, are geographical rather than structural variables. The place yields these attributes, not its industrial structure.

Results

The results of the study are outlined in the following sections.

No Allocational Constraints

The efficient frontier generated with no allocational constraints contains seventeen corner portfolios. These corner portfolios represent risk (i.e., covariance) minimizing allocations over the range of return intervals (i.e., mean value of shipments per employee) (see Table 2). Return and risk increase monotonically, but not linearly, over the efficient frontier. The optimum allocation of the firm's production, given the assumptions of our application, is based on the firm's utility function. The specific efficient portfolio selected, therefore, is based on the firm's risk-return preference.

The first corner portfolio describes the overall risk-minimizing allocation of production. It places approximately 75% of production in Miami and 25% in San Diego. No other combination of SMSAs or any single SMSA, can outperform this combination in regard to the minimization of output variability. The strong relative contribution of Miami to the initial corner portfolios can be attributed to the low variance associated with the SMSA over the period (see Table 1). However, the covariance between Miami and San Diego had a much lower value than did the variance of Miami alone. Miami's overall contribution to the efficient frontier decreases as the return level increases. Because of low mean output over the period, Miami is driven out of the efficient portfolio when the tenth corner is reached. Houston, at the other extreme, has the entire allocation of production in the seventeenth corner solely because it had the greatest mean value of shipments per employee over the period.

Except for corners 14 (all Kansas City) and 17 (all Houston) the efficient frontier is characterized by geographical diversification. Also, most of the individual corner portfolios allocate production to SMSAs located in different regions. The obvious example is corner portfolio 1 with its allocation to Miami and San Diego. When SMSAs in the same region are included in a corner portfolio, one of the SMSAs typically has a very small allocation. For example, corner portfolios 9, 10, and 11 contain both Detroit and Youngstown, but Youngstown's allocations are only about 5%. The degree of spatial dispersion in most of the corner portfolios can be expected, given the type of neighborhood effect in the American urban system (e.g. Jeffrey et al, 1969).

At least some of this neighborhood effect is related to similarity of industrial structure. However, it must be noted that the difference between corner portfolios 11 and 12 switches allocation from Detroit to Kansas City. Although these SMSAs play a similar role in each corner's composition, their industrial structures are dissimilar. Moving from corner 15 to corner 16, a switch is made between Gary and Houston. In both examples the return intervals are small, so they both provide some evidence that the

Table 2.
The Efficient Frontier with No Allocational Constraints

	Portfolio Composition											
Corner Portfolio	Miami	San Diego	San Jose	Grand Rapids	Detroit	Seattle	Youngstown	Kansas City	Gary	Houston	Return*	Risk**
1	.748	.252									29,020	73,984
2	.744	.256									29,042	74,158
3	.739	.248	.012								29,156	76,129
4	.732	.226		.042							29,311	79,144
5	.652			.348							31,279	133,014
6	.628			.372							31,527	144,825
7	.622			.367	.011						31,758	159,346
8	.396			.164	.255	.185					38,260	907,576
9	.114				.410	.424	.052				48,235	3,284.152
10					.454	.504	.042				50,685	4,098,466
11					.464	.488	.048				50,790	4,137,380
12						.525	.015	.460			53,670	5,438,643
13							.044	.956			60,264	12,080,986
14								1.000			60,525	12,499,145
15								.984	.016		60,723	13,072,007
16								.942		.058	61,400	15,604,819
17										1.000	75,651	222,752,640

Notes: * Mean value of shipments per employee
** Covariance or variance (if allocation = 1.0)

Table 3.
Efficient Frontiers Under Allocational Constraints: Selected Frostbelt Cities

A. Detroit = .500

Corner Portfolio	Detroit	Miami	Youngstown	Seattle	Kansas City	Gary	Houston	Return	Risk
1	.500	.500						40,723	1,834,000
2	.500	.498	.002					40,790	1,842,022
3	.500		.025	.475				50,851	4,172,971
4	.500			.978	.422			56,659	9,143,211
5	.500				.500			57,118	9,821,011
6	.500				.481	.019		57,350	10,399,524
7	.500				.432		.068	58,148	13,174,044
8	.500						.500	64,680	25,522,016

B. Hartford = .500

Corner Portfolio	Hartford	Miami	Seattle	Kansas City	Houston	Return	Risk
1	.500	.500				29,838	2,312,300
2	.500		.500			39,789	5,081,614
3	.500			.500		46,232	11,558,860
4	.500				.500	53,794	41,038,454

Table 3. continued

C. New York City = .500

Corner Portfolio	New York City	Miami	Seattle	Detroit	Kansas City	Houston	Return	Risk
1	.500	.500					30,485	475,780
2	.500	.211	.289				34,681	961,317
3	.500		.399	.101			41,046	2,327,723
4	.500		.384	.116			41,141	2,355,313
5	.500		.387		.113		41,889	2,602,919
6	.500				.500		46,879	6,208,070
7	.500					.500	54,442	22,544,241

Table 4.
Efficient Frontiers Under Allocational Constraints:
Selected Sunbelt Cities

A. Phoenix = .500

Corner Portfolio	Phoenix	Miami	Seattle	Detroit	Kansas City	Houston	Return	Risk
1	.500	.500					32,237	1,043,901
2	.500	.108	.392				40,028	2,458,112
3	.500		.462	.038			42,417	3,143,147
4	.500		.428	.072			42,625	3,217,645
5	.500		.430		.070		43,089	3,412,054
6	.500				.500		48,631	8,095,756
7	.500					.500	56,193	32,803,615

B. Los Angeles = .500

Corner Portfolio	Los Angeles	Miami	Seattle	Detroit	Kansas City	Houston	Return	Risk
1	.500	.500					34,418	2,308,325
2	.500	.412	.088				42,623	4,553,233
3	.500		.470	.030			44,554	5,286,425
4	.500		.429	.071			44,803	5,399,652
5	.500		.431		.069		45,262	5,642,078
6	.500				.500		50,812	10,936,924
7	.500					.500	58,375	48,379,355

Table 4. continued

C. Dallas = .500

Corner Portfolio	Dallas	Miami	San Jose	Seattle	Wilmington	Kansas City	Houston	Return	Risk
1	.500	.500						32,941	1,118,379
2	.500	.497	.003					32,971	1,121,019
3	.500	.357		.143				35,796	1,461,338
4	.500	.290		.210				38,706	1,994,815
5	.500	.138		.346	.016			40,189	2,334,994
6	.500			.445	.020	.035		43,406	3,210,151
7	.500			.433		.067		43,758	3,321,791
8	.500					.500		49,335	7,521,331
9	.500						.500	56,898	27,351,236

efficient frontier generated by the model is based on some elements of multiregional diversification rather than on structural diversification alone. In addition, while the mean value of shipments per employee is probably biased by industrial structure in such specialized SMSAs as Gary (steel) and Houston (petroleum), the results of the portfolio model also indicate that geography is more important than industrial structure portfolio risk, as measured by inter-regional covariance during the volatile period of 1971-76.

The importance of industrial structure can be easily overemphasized in interregional analysis. Thirlwall (1966), for example, argued that regional economies are subject to important influences beyond the industrial structure. This researcher suggested that it cannot be assumed that all regions track coincidentally on the same business cycle, even if their industrial structures were identical. More importantly, Gertler's (1984) rigorous empirical analysis of business and investment cycles across both regions and industries led to the finding that industrial structure is a useless concept in business cycle analysis.

Biased Portfolios

The second application of the model is to a set of SMSA-biased portfolios. These portfolios are not efficient in a pure sense, because some of their allocation is fixed outside the model. In these cases it is assumed that 50% of a firm's production is fixed in a particular SMSA. Given this constant proportion, an efficient "branching" frontier can be generated. Six SMSA-biased portfolios are considered; three focus on "Frostbelt" SMSAs, and three concern "Sunbelt" SMSAs.

The three Frostbelt SMSAs are Detroit, Hartford, and New York (see Table 3). The biased Frostbelt portfolios represent paths toward efficient diversification that are similar to those described without allocational constraints. Miami is the efficient partner at low levels of return and Houston is the efficient partner for diversification at high levels. This result occurs because those cities comprising the general efficient frontier make up an efficient diversification network in the American urban system. Therefore, as in the general case, there is a significant degree of spatial dispersion along the biased efficient frontiers.

The efficient frontiers of the three Sunbelt SMSAs of Phoenix, Los Angeles, and Dallas are described in Table 4. As in the Frostbelt case, each of these biased portfolios tracks on an efficient frontier that is tied into the general efficient diversification network. All three of these cases again begin with Miami in corner portfolio 1 and end with Houston in the last corner. Comparison of the Frostbelt and Sunbelt portfolios indicates that efficient diversification paths are asymmetrical in biased cases. For example, portfolios biased toward New York City, Phoenix, and Los Angeles have Detroit on their efficient frontiers. The Detroit portfolio, however, does not contain any of these SMSAs, resulting partially from the role of Detroit in the efficient diversification network. A built-in bias also exists that fixes each SMSA on a diversification path based both on the area's unique variance and its covariance with the efficient diversification network.

Conclusion

Because diversified multiregional portfolios consist of weakly-correlated regions, application of portfolio methodology to interregional research has a quite different focus than does previous work on interregional relationships. The primary purpose of most earlier research into such relationships has been the identification of clusters of areas that behave similarly over the course of a national business cycle or that can be defined as a cohesive group with a discernible subnational cycle. Such clusters have been constructed on the basis of both coincident (Hanham, 1984; Jeffrey, 1974; Jeffrey et al, 1969; King and Forster, 1973), and, in the interest of describing geographical transmission, lagged economic indicators (Bassett and Haggett, 1971). Portfolio analysis of interregional structures is in juxtaposition to the design of these related clusters: the purpose of such analysis at this scale is the identification of a cluster of unrelated regions. Each of the regions in the portfolio is affected by the national economic trend either in a different way or at a different time, yet the analytical result is the same. In this sense, geographical portfolio diversification is a reaction to the uneven regional incidence of economic fluctuations as modeled by Jones (1983, 1984).

The policy implications of this analysis are that although the industrial heartland is in an industrial decline, firms may follow a pattern of geographical diversification as a risk-aversion strategy, and that this situation may stabilize once risk reaches a form of equilibrium. If theoretical portfolio geographical diversification is a factor in the recent decentralization of industry, then the results of the model have implications for public policy decisions regarding industrial development in a spatial context. Such recruitment and retention policy for manufacturers focuses largely on limiting the firms' operating costs via such instruments as industrial revenue bonds and tax abatements at both state and municipal levels, as well as proposed federal legislation concerning Enterprise Zones.

Alternative policies, however, could concentrate on risk, rather than cost, containment. The Italian policy of requiring that certain proportions of government purchases be made from firms in the Mezzogiorno is an

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