Division of Research
Graduate School of Business Administration
The University of Michigan

January 1974

PRODUCTIVITY AND REGIONAL MATURITY AN ANALYSIS OF MICHIGAN'S POST-WAR ECONOMY

Working Paper No. 89

by

Gary D. Potts

The analysis reported here is part of a study of regional economics, specifically a study of Michigan's economy, which is being conducted jointly by two units of The University of Michigan, the Division of Industrial Development at the Institute of Science and Technology and the Division of Research at the Graduate School of Business Administration. This paper is a result of work pursued during the summer and fall of 1973 under these joint auspices.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES--Continued

FIGURES

INTRODUCTION AND OVERVIEW

The system of incentives and rewards under which our free enterprise economy was designed to function has led economists to believe that the allocation of productive resources will flow to the most efficient users. Through innovation, competition,and rational decision-making, the most productive entities will prosper and grow. It is not surprising, then, that the study of regional economic growth has led researchers to the concept of productivity--the benefit derived from some measurable unit of input or combination of inputs.

Previous economic and statistical research has indicated that productivity can be a very important concept in any analysis of regional development. Harvey S. Perloff, in collaboration with others, has contributed one of the most useful accounts of regional economic growth in the United States.[1/] The level of wages, and hence per capita real income, was found to be positively associated with the relative capital-output ratios of production in a region. High rates of growth in employment and output were also associated with the income elasticity of demand for goods produced in a region, and the year-to-year gains in output per man-hour exhibited by the labor force.

1/ H.S. Perloff, with Vera W. Dodds, How a Region Grows (1963: Committee for Economic Development), pp. 109-10.

The most comprehensive studies of productivity have been contributed by John W. Kendrick and the National Bureau of Economic Research.[2/] Kendrick's assessments of the nature of productivity measurement and growth on the macroeconomic level have provided the framework for many subsequent works. These studies also support the conclusion that growth in employment and output is associated with increasing productivity.

Furthermore, surveys have shown that regional productivity is one of the prime factors influencing industrial location decisions, especially when inter-regional wage differentials exist.[3/]

To the casual observer, the concept of productivity can sometimes become unclear.[4/] Productivity advance often has a connotation of "production speed-up" implemented by managers fitting the "efficiency expert" stereotype. However, increasing output per unit of input (traditionally man-hours

---

2/ J. Kendrick, Productivity Trends in the U.S. (1961: NBER). Also, see Domar, "On Total Productivity and All That," Journal of Political Economy (Dec. 1962), pp. 597-608, for a fine critique. An alternative approach is presented by R.M. Solow, "Technical Change and the Aggregate Production Function," The Review of Economics and Statistics (Aug. 1957), pp. 312-20.

3/ E. Mueller, A. Milken, and M. Wood, Locational Decisions and Industrial Mobility in Michigan (1961, Institute of Social Research, University of Michigan).

4/ For a deeper discussion, see Jerome A. Mark, "Concepts and Measures of Productivity," in Herbert Stein, ed. Meaning and Measurement of Productivity (1971: U.S. Dept. of Labor, Wash., D.C.) and C.J. Grayson, "How to Make Productivity Grow Faster," Business Week (July 14, 1973: McGraw-Hill, Inc.) page 15-16.

of labor) can result from a variety of factors, some of which are:

1. substitution of capital for labor
2. technological advance
3. economies of scale
4. increasing labor force skill
5. improved management techniques or more harmonious labor-management relations yielding increased job satisfaction and improved working conditions.

Viewing productivity as the yard stick for the measurement of the net effect of these forces on productive efficiency can be extremely useful in economic analysis.

The efficiency of input factors provides one dimension of the growth process. A regional economy must also strive to maintain an employment base necessary to support increases in population and labor force at acceptably low levels of unemployment. The constraints upon employment growth involve the net productive capacity of economic entities in a region. Increases in regional capacity, and hence the ability to support additional employment, is determined by the demand for goods produced in the area relative to other regions, as well as the amount and allocation of capital investment.

This study's essential objective is to provide insight into the forces influencing industrial growth or decline in Michigan. We will attempt to determine whether or not growth in employment and output in Michigan's industrial sectors can be expected as a natural market reaction to increasing productivity and efficiency. We will also attempt to trace historical patterns of capital spending in these sectors and determine what effect these outlays have on net productive capacity, employment, and output.

For the purposes of this analysis, the state's industrial mix will be examined by isolating the eight largest product-oriented sectors. The sectors were selected on the basis of their relative importance to the state's economy. In 1971, they accounted for 74 per cent of total state employment and 70 per cent of total state value added from industrial sources. The sectors are:

1. SIC 20--Food and Kindred Products
2. SIC 26--Paper and Allied Products
3. SIC 28--Chemicals and Petroleum Products
4. SIC 33--Primary Metals Manufacturing
5. SIC 34--Fabricated Metals Manufacturing
6. SIC 35--Nonelectrical Machinery Manufacturing
7. SIC 36--Electrical Machinery Manufacturing
8. SIC 37--Transportation Equipment Manufacturing

First I shall examine post-war trends in Michigan's productivity, output, employment, and capital expenditures in each sector both in absolute terms and in comparison to national levels. Secondly, I shall develop a central growth hypothesis as a means of explaining the inter-industrial patterns of growth in Michigan and how the relative importance of each factor might be estimated by statistical modelling. And finally, armed with this information, I shall translate some interpretations of Michigan's industrial development prospects into policy recommendations.

A HISTORICAL PROFILE OF MICHIGAN INDUSTRY

As we begin this study of Michigan's industrial growth prospects, it is appropriate to delineate historical trends by sector for selected economic parameters. The purpose of this section is to trace post-war movements in productivity, employment, real value added and real capital expenditures and to relate Michigan's performance to that of the national economy.[5/]

Tables I through VIII provide historical profiles for each major industrial sector.[6/] Part A in each table is devoted to the productivity performance of Michigan's labor. Real value added per production worker man-hour for Michigan's labor is compared to the national average in each sector. Michigan's productivity as a proportion of the national average is shown as the "productivity quotient." Additionally, output per man-hour is weighted by average wage rate to allow for regional differentials in production worker wages for comparison.

5/ Value added is derived by subtracting the costs of intermediate goods and other inputs from the gross value of shipments. It is considered the best measure of relative economic importance of manufacturing among industries and regions because it avoids double-counting.

6/ The source of data for Tables I-VIII is U.S., Bureau of the Census, Annual Surveys of Manufactures, 1950-71 (Washington, D.C.: U.S. Government Printing Office). Price data used in adjusting to real terms was obtained from U.S. Dept. of Labor, Business Statistics (Washington, D.C.: U.S. Government Printing Office).

Part B in each table shows absolute and relative movements in employment, real value added and real capital expenditures over time. Growth in each major sector is compared to the growth in all Michigan manufacturing in order to provide a measure of the relative importance of the sector to the state's economy. Each sector's growth is also compared to the growth in the national or aggregate sector in the form of a share for each parameter. The reader is then able to view a sector's inter-regional as well as inter-industrial growth. The regional share approach will provide the basis for much of the analytical work to be presented in the following sections.

As would be expected, Michigan has generally displayed appreciable growth in each category in absolute terms. The industrial mix of the state's economy has, for the most part, remained essentially constant. However, when the comparative measures of productivity--employment, output, and incremental investment--are viewed the dynamics of inter-regional growth become more vivid.

Powered by rapid expansion of automobile demand, Michigan reaped the benefits from accelerated economic development in the early part of the century. The region's economic strength came from rapid growth in durable goods, especially as inputs to automobile production. In 1950, output per man-hour was two and sometimes nearly three times that of the national average in each sector. As these traditional primary industries (autos, heavy

Table I

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 37-TRANSPORTATION EQUIPMENT MANUFACTURING

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor (1967$)	5.59	8.11	13.46
U.S. Average	3.11	7.64	15.60
Michigan Productivity Quotient	1.79	1.06	.86
Real Value Added per Production Wage			
Michigan Labor	2.18	2.37	3.10
U.S. Average	1.27	2.36	3.06

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	360.6	237.4	246.0
Percentage of Total Mich. Manufacturing	42.39	34.38	33.76
Percentage of U.S. Sector Total	35.85	20.54	20.74
Real Value Added			
Mich. Sector Total (in Million $)	4135.6	3987.9	6760.9
Percentage of Total Mich,Manufacturing	42.07	36.78	37.29
Percentage Share of U.S. Sector Total	48.38	21.64	20.67
Capital Expenditures			
Mich. Sector Total (in Million $)		228.7	302.5
Percentage of Total Mich. Manufacturing		30.85	31.06
Percentage of U.S. Sector Total		28.01	24.35

Table II

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 35-NONELECTRICAL MACHINERY MANUFACTURING

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor	6.66	7.96	11.70
U.S. Average	2.53	6.47	14.98
Michigan Productivity Quotient	2.63	1.23	.78
Real Value Added per Production Wage			
Michigan Labor	2.55	2.34	2.99
U.S. Average	1.11	2.17	4.43

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	107.6	97.8	93.5
Percentage of Total Mich. Manufacturing	12.64	14.16	12.83
Percentage of U.S. Sector Total	10.11	9.66	7.87
Real Value Added			
Mich. Sector Total (in Million $)	1488.1	1585.9	2155.1
Percentage of Total Mich. Manufacturing	12.70	13.43	12.12
Percentage of U.S. Sector Total	16.90	11.02	7.02
Capital Expenditures			
Mich. Sector Total (in Million $)		50.9	70.7
Percentage of Total Mich. Manufacturing		6.86	7.26
Percentage of U.S. Sector Total		6.50	9.14

Table III

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 34-FABRICATED METALS MANUFACTURING

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor	5.91	6.57	9.86
U.S. Average	2.48	5.60	13.98
Michigan Productivity Quotient	2.38	1.17	.70
Real Value Added per Production Wage			
Michigan Labor	2.44	2.29	2.71
U.S. Average	1.33	2.08	3.96

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	94.5	66.1	96.8
Percentage of Total Mich. Manufacturing	11.12	9.57	13.28
Percentage of U.S. Sector Total	11.72	8.02	9.80
Real Value Added			
Mich. Sector Total (in Million $)	1157.9	907.0	1929.0
Percentage of Total Mich. Manufacturing	10.38	7.71	11.51
Percentage of U.S. Sector Total	18.64	8.78	11.01
Capital Expenditures			
Mich. Sector Total (in Million $)		45.6	64.2
Percentage of Total Mich. Manufacturing		6.32	6.59
Percentage of U.S. Sector Total		6.50	9.14

Table IV

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 33-PRIMARY METALS MANUFACTURING

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor	6.00	7.66	9.49
U.S. Average	2.55	7.01	9.56
Michigan Productivity Quotient	2.35	1.09	.99
Real Value Added per Production Wage			
Michigan Labor	2.38	2.23	2.34
U.S. Average	1.09	2.10	2.67

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	72.8	66.8	73.9
Percentage of Total Mich. Manufacturing	8.55	9.67	10.14
Percentage of U.S. Sector Total	7.45	6.94	7.71
Real Value Added			
Mich. Sector Total (in Million $)	946.0	1029.0	1418.6
Percentage of Total Mich. Manufacturing	8.26	9.20	8.46
Percentage of U.S. Sector Total	11.89	7.70	7.41
Capital Expenditures			
Mich. Sector Total (in Million $)		157.5	182.4
Percentage of Total Mich. Manufacturing		21.25	18.73
Percentage of U.S. Sector Total		9.02	6.99

Table V

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 20-FOOD AND KINDRED PRODUCTS

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor	5.23	10.42	16.19
U.S. Average	3.80	7.51	11.78
Michigan Productivity Quotient	1.37	1.38	1.37
Real Value Added per Production Wage			
Michigan Labor	2.86	4.05	5.17
U.S. Average	2.13	3.21	4.39

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	37.2	37.5	31.4
Percentage of Total Mich. Manufacturing	4.37	5.43	4.30
Percentage of U.S. Sector Total	3.46	3.25	2.86
Real Value Added			
Mich. Sector Total (in Million $)	422.3	796.0	1023.3
Percentage of Total Mich. Manufacturing	4.76	6.56	5.85
Percentage of U.S. Sector Total	4.18	4.15	3.48
Capital Expenditures			
Mich. Sector Total (in Million $)		47.4	47.5
Percentage of Total Mich. Manufacturing		5.85	4.88
Percentage of U.S. Sector Total		3.74	2.61

Table VI

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 26-PAPER AND ALLIED PRODUCTS

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor	5.68	7.62	7.77
U.S. Average	2.67	6.24	9.10
Michigan Productivity Quotient	2.12	1.22	.85
Real Value Added per Production Wage			
Michigan Labor	2.55	2.44	2.43
U.S. Average	1.36	2.37	2.99

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	24.2	23.1	20.2
Percentage of Total Mich. Manufacturing	2.84	3.34	2.77
Percentage of U.S. Sector Total	6.05	4.97	4.41
Real Value Added			
Mich. Sector Total (in Million $)	314.3	357.5	334.9
Percentage of Total Mich. Manufacturing	2.87	3.05	1.89
Percentage of U.S. Sector Total	9.15	5.45	3.80
Capital Expenditures			
Mich. Sector Total (in Million $)		27.7	57.6
Percentage of Total Mich. Manufacturing		3.75	3.81
Percentage of U.S. Sector Total		5.92	5.94

Table VII

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 28-CHEMICALS AND PETROLEUM PRODUCTS

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor	9.49	14.17	24.90
U.S. Average	6.48	15.10	29.27
Michigan Productivity Quotient	1.46	.93	.85
Real Value Added per Production Wage			
Michigan Labor	3.96	4.24	5.90
U.S. Average	2.88	4.91	8.35

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	25.6	26.3	20.6
Percentage of Total Mich. Manufacturing	3.00	3.80	2.82
Percentage of U.S. Sector Total	4.15	3.80	3.29
Real Value Added			
Mich. Sector Total (in Million $)	508.2	741.1	1021.0
Percentage of Total Mich. Manufacturing	6.11	6.94	5.28
Percentage of U.S. Sector Total	5.42	4.19	2.91
Capital Expenditures			
Mich. Sector Total (in Million $)		85.0	61.1
Percentage of Total Mich. Manufacturing		11.48	6.27
Percentage of U.S. Sector Total		4.32	1.77

Table VIII

HISTORICAL PROFILE OF MICHIGAN INDUSTRY IN SIC 36-ELECTRICAL MACHINERY MANUFACTURING

A. Productivity

Real Value Added per Production Man-Hour	1950	1960	1971
Michigan Labor	6.66	7.96	10.52
U.S. Average	2.53	6.82	13.98
Michigan Productivity Quotient	2.63	1.16	.75
Real Value Added per Production Wage			
Michigan Labor	2.57	2.64	4.11
U.S. Average	1.18	2.63	4.52

B. Regional Growth Parameters

Employment	1950	1960	1971
Mich. Sector Total (in Thousands)	13.8	24.2	28.5
Percentage of Total Mich. Manufacturing	1.62	3.50	3.91
Percentage of U.S. Sector Total	2.28	2.54	2.54
Real Value Added			
Mich. Sector Total (in Million $)	149.8	357.2	597.5
Percentage of Total Mich. Manufacturing	1.38	3.27	3.22
Percentage of U.S. Sector Total	3.12	2.91	2.14
Capital Expenditures			
Mich. Sector Total (in Million $)		12.9	24.6
Percentage of Total Mich. Manufacturing		1.46	2.04
Percentage of U.S. Sector Total		1.86	2.54

machinery, chemicals) began to expand markets geographically, Michigan's industrial position became less dominant. Rates of growth in productivity were much greater in regions outside of Michigan, and by 1971 the state's output per man-hour fell below that of the national average in seven of the eight major sectors (six of which are durable goods) as illustrated in Figure 1. The only exception to the pattern of decline occurred in Food and Kindred Products manufacturing, which remained essentially stable in all parameters over the period.

A region which specializes in durable goods production has a potential for high rates of economic growth. However, as Michigan has found, there is an inherent instability caused by sensitivity to the aggregate business cycle. Severe dips in industrial employment, even for short periods of time, can generate social problems of immense magnitude for a region. Michigan's automobile sector has displayed an annual decrease in employment of production workers of as large as a 30 per cent (occurring in the 1958 recession), as shown in Figure 2.

Indeed, a published U.S. Department of Commerce study found that of all states Michigan has displayed the greatest income sensitivity to aggregate economic fluctuations.[7/]

7/ R.B. Bretzfelder, "Sensitivity of State and Regional Income to National Business Cycles," Survey of Current Business (U.S., Dept. of Commerce) Apr. 1973, pp. 22-35.

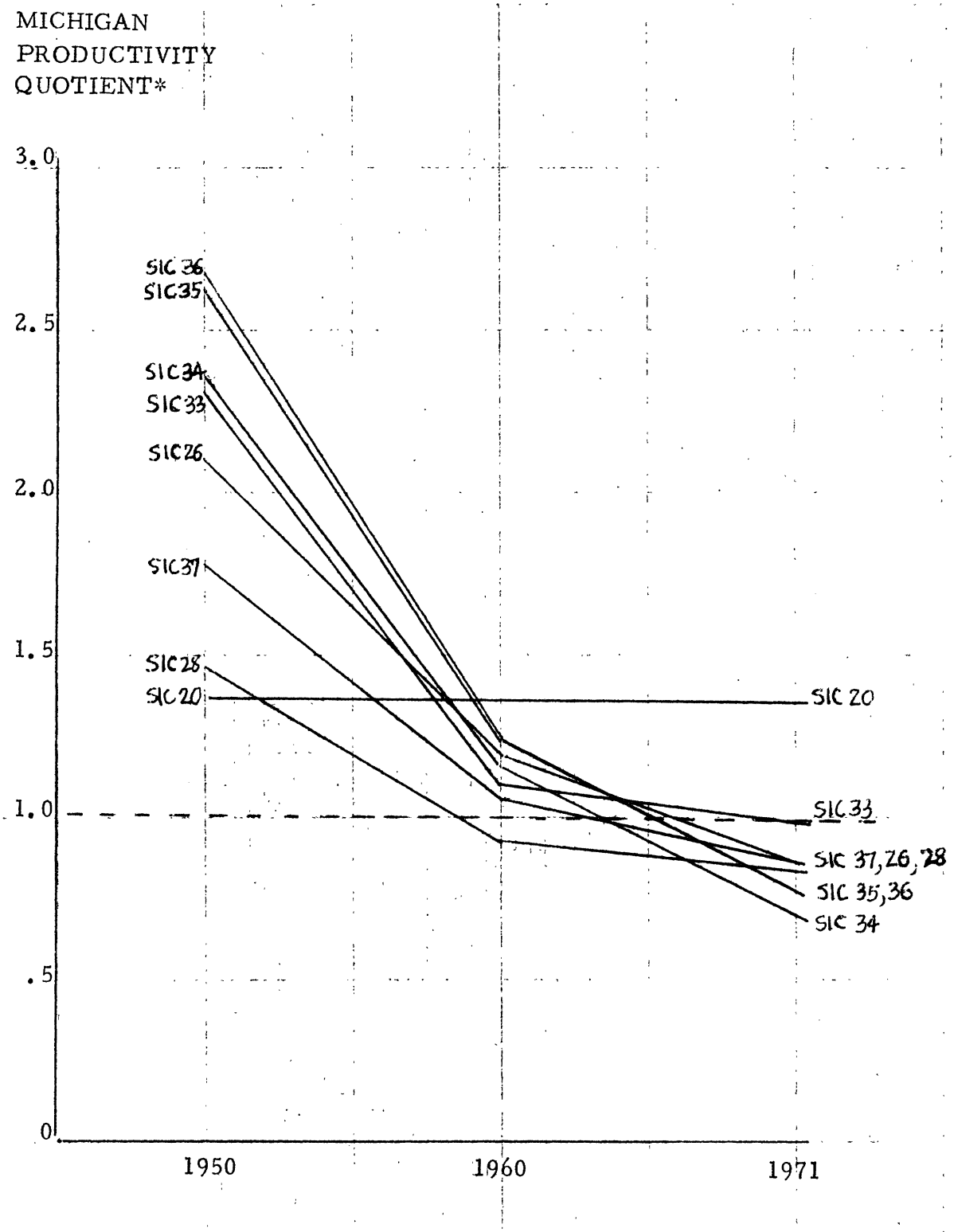

Figure 1. MICHIGAN PRODUCTIVITY QUOTIENTS, BY SECTOR

*Mich. Prod. Quot. = Michigan Productivity/National Average Productivity

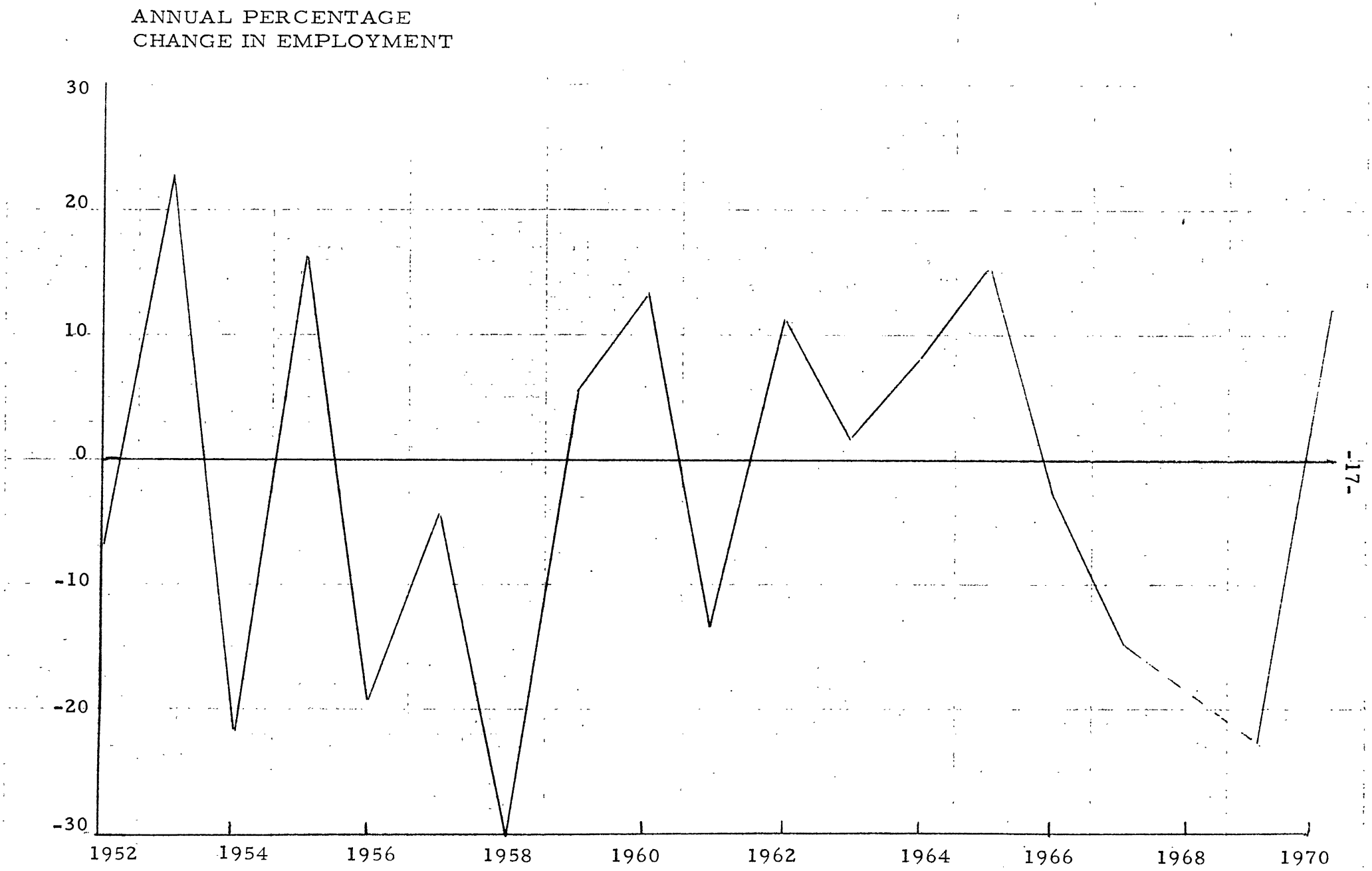

Figure 2. MICHIGAN TRANSPORTATION EQUIPMENT SECTOR, ANNUAL EMPLOYMENT CHANGES

Therefore, in assessing Michigan's industrial development patterns it is also important to evaluate how each state sector has reacted to the business cycle, especially in comparison to the reactions of the state's transportation equipment sector. Table IX below shows the results of a correlation analysis of annual changes in employment between each major sector and the automobile industry. A high positive correlation would substantiate the premise that there is a high degree of interrelation between the state's industries adding to the "risk of unemployment," given regional predominance in automobile manufacturing.

Table IX

MICHIGAN ECONOMY--CORRELATION OF ANNUAL SECTOR EMPLOYMENT CHANGES WITH AUTO INDUSTRY, 1949-67

Sector	Correlation Coefficient
Food	.05
Electrical Machinery	.36
Chemicals	.43
Nonelectrical Machinery	.67*
Fabricated Metals	.79*
Paper	.80*
Primary Metals	.83*

*Significant at 99% confidence.

The food industry displayed the lowest correlation with the automobile industry in employment movement, mainly because of the fact that the

demand for food is less income-elastic and is more likely a function of population growth. The electrical machinery industry is primarily comprised of automobile replacement parts manufacturing (SIC 3694) in Michigan. Therefore, a natural countercyclical tendency exists. When demand for new cars is low, people tend to repair their existing vehicles in the interim. As expected, the other machinery and metal fabricating sectors are highly dependent upon automobile demand and have provided little capability to absorb excess unemployment during Michigan's lean years.

This, then, is the historical setting for the analyses to follow. Now let us attempt to identify some of the specific factors underlying these patterns.

A GENERAL GROWTH HYPOTHESIS

The most challenging aspect of this study is to suggest a feasible, clear, and empirically testable hypothesis which would provide insight into the reasons for Michigan's industrial growth or decline by major sector. Hopefully, the ideas which follow will accomplish this task.

When economists survey regional economic growth and development in the United States, certain factors easily predominate. These are:

1. the transition from primarily agricultural to industrial activities
2. the expansion of markets by increased transport capabilities
3. the distribution of regional advantages with respect to natural resources, intermediate market access, and specialization of productive resources

However, one has the feeling that these historical factors do not relate to the manner in which regions grow today, nor do they reflect the rate at which expected industrial growth will take place. Rather, regional growth will conceivably be brought about by shifts in productive emphasis from one sector to another, either shifts from low- to high-valued goods or shifts from manufacturing to service-related output. As regions mature capturing new geographical markets and natural resources will likely play a smaller role in economic progress.

Furthermore, one must consider the implications of the tendency toward conglomeration of industrial and labor union power across regions and the willingness of the federal government to impose controls on the national economy at various levels. Given these influences one might expect profit-oriented companies to emphasize cost-reducing technology rather than upward price adjustments.

Hence a region's ability to grow industrially would seem to be dependent upon the efficiency and effectiveness of the combination of productive inputs as they are reflected in traditional measures of productivity. Productivity, in output-per-unit-of-input terms, represents current changes in technology, managerial expertise, and supply of intermediate materials,as well as labor force skill, attitudes and working conditions.

The growth of regional industry is also believed to be highly dependent upon the flow of capital services and the capacity-creating function served by

incremental investment. In order to attempt a realistic analysis of the influences of investment and productive capacity, one would need to allow capital growth rates to vary. Domar, in his post-Keynesian theory of economic growth, suggests that total employment is a function of effective demand and productive capacity.[8/] This is a departure from the Keynesian treatment of productive capacity, in which it is assumed to be constant. Investment, in Keynes's theory, serves only to create income through the multiplier effect. The treatment of investment as a generator of changes in productive capacity as well as income allows us to confront the complex nature of the growth process, as Domar so cogently explains.

Accurate measurement of "productive capacity," or even total agreement upon what the concept implies remains a challenge, especially under varying rates of physical depreciation and technical obsolescence of assets across industries and regions. The measurement of productive capacity and other variables will be discussed in the following section.

Three major concepts have now been put forth in an attempt to formulate an analytical framework. The central hypothesis to be tested here is that the ability of a major industrial sector to grow within Michigan relative to other areas of the country is dependent upon its year-to-year gains in labor productivity through efficiencies and economies of the manufacturing process, the

---

8/ E.D. Domar, Essays in the Theory of Economic Growth (New York: Oxford University Press, 1957) p. 73.

state's ability to attract investment annually, and the extent to which this investment adds to the sector's net productive capacity.

TESTING THE HYPOTHESIS

What are the most appropriate measures for quantifying the influences mentioned in the preceeding section and what are their limitations?

The variables which seem most appropriate as measures of Michigan's industrial growth relative to other areas are the state's share of U.S. total real value added by industry and its corresponding share of employment of production workers. Many people believe that the state's major responsibility lies with the formulation of policies which would add to the well-being and prosperity of the population. Rising levels of output and employment lead to gains in per capita real income, a principal measure of social well-being. Hopefully, the use of regional share as dependent variables would minimize any distortion or influence exogenous to Michigan and would indicate implicitly the state's ability to compete with other areas for jobs and output. Variance in regional share would, in short, reflect differentials in the rate of growth or decline between a region and the national average or aggregate.

For now, the environmental issues which are raised about the wisdom of continued economic growth will not be confronted. Let us assume that measures or controls protecting the environment are enacted as constraints or influences upon the existing manufacturing technology.

Relative first differences in the productivity of Michigan's labor (the change in real value added per man-hour from one year to the next as a

proportion of the preceding year's level) will be examined as an explanatory variable reflecting productive efficiency. This mathematical technique is often used in time series analysis and provides a good measure of relative movements in a variable while nicely removing the artificial influence of trend which is so often present.[9/] For the purposes of discussion, variables which have been transformed into relative first differences will be labelled "relative changes."

Growth in output per man-hour would presumably act to lessen unit variable costs, and prices, and hence it would increase final demand and ability to compete. With levels of demand rising, one would also expect a larger share of value-added and employment accruing to the state if the proposition that productive resources flow to the most efficient users is accepted.

However, in the use of a traditional productivity variable it is necessary to consider the rather intuitive feeling that output per unit of input tends to be greater in periods of high demand. Presumably a result of the intensity of resource utilization and economies of scale, this statistical behavior in an independent variable would likely reflect symptomatic rather than causal tendencies. Although nothing concrete can be ascertained about true causation in an analysis such as this, from a modeling standpoint it would be desirable to provide as much evidence as at all possible for the existence of causal tendencies.

9/ D.A. Leabo, Basic Statistics (1972: Irwin, Inc., Homewood, Ill.) pp. 445-46.

The extent of the sensitivity of productivity to demand fluctuations would seem to depend on the measure of labor input used in the calculation of productivity. Labor input reflecting both direct and indirect labor hours, such as Kendrick uses in his macroeconomic studies, would certainly contain a fixed or "overhead" component and introduce unwanted bias. It is felt that producers hesitate to reduce employment as a reaction to a decline in demand if the downturn is expected to be short-term, because presumably these displaced workers would have to be rehired in the event of a recovery. The tendency, then, would likely be to manage short-term fluctuations in demand by adjustments in the scheduling of direct labor hours. Hence, the use of production worker man-hours for computing productivity would leave out much, if not all, of the influence of external market fluctuations on output per unit of input.10/

In order to offer evidence as to the validity of this assumption, the reader is invited to examine Table X, which lists the results of a correlation analysis between relative changes in production man-hours and relative changes in output produced. High positive correlation would indicate high sensitivity of annual man-hour scheduling of direct labor to annual changes in demand as measured by levels of real value added. Given this evidence from the sample, it would seem to lend credibility to the treatment of productivity as it is presented here as a determinant of regional growth. Again, the productivity growth measures used should provide a meaningful barometer for the influence of changes in internal productive efficiency and the effectiveness of all input factors.

10/ It should be noted that overtime hours are accounted for in government surveys as straight time, rather than time-and-a-half as is commonly done within firms.

Table X

ASSOCIATION BETWEEN CHANGES IN PRODUCTION MAN-HOURS AND CHANGES IN OUTPUT

Michigan Industry	Correlation Coefficient $X_{29.31}$*
Food	.74
Paper	.78
Chemicals	.67
Primary Metals	.94
Fabricated Metals	.96
Nonelectrical Machinery	.94
Electrical Machinery	.87
Transportation Equipment	.97

*All significant at .01

The second major explanatory consideration is the state's ability to generate or attract investible funds under a given set of conditions in external capital markets. The state's share of national capital expenditures in an industry is suggested as the most appropriate measure, and would seemingly reflect a myriad of other influences--namely the wealth of the state's industry resulting from profitability and the flow of reinvested earnings, the dividend preferences of stockholders, as well as the general management approach to financial planning and capital budgeting. This variable could also reflect general organizational goals with respect to expansion, and whether spending plans are laid out far in advance, or as reactions to capital consumption in prior periods or near-term expectations. Michigan's share of output and employment in an industry can be expected to be positively influenced by its share of capital spending regardless of its intended use, with the effects being realized in the current period, the following period, or both.

Even though it is presupposed that Michigan's share of annual capital expenditures will have an ultimate effect on share of markets, and employment of production workers, a measure of incremental capacity growth would likely complement the analysis.

In Domar's theoretical analysis of economic growth,[11/] he supports the theory that rates of capacity expansion should be considered dynamic and

---

11/ Domar, Essays, p. 73.

that some measure of potential productivity of capital could be developed in order to determine the necessary rate of growth of net investment for the maintenance of full employment. It is felt that these ideas could be applied to a regional industrial sector in order to provide some insight as to the rates of growth in productive capacity. It is for this purpose that the variable called the "marginal productivity of capital" (X_{24}) has been introduced. Though computed much like a "marginal product of capital," this variable should not be confused with a marginal product in a theoretical sense because a pure marginal analysis must hold all other influences constant. Defined as the ratio of change in annual value-added to new capital expenditures, it does reflect various important economic influences.

It may be beneficial to remind the reader here that annual estimates of total "accumulated" net investment are not available at either the regional or industry level. One can only draw inferences about the nature of new expenditures as they reflect in this capital productivity figure. For instance, low values for the estimated marginal productivity of capital may reflect nonproductive allocations of capital in a regional industry, caused by or associated with:

1. movements along the production function, resulting in substitution of capital for labor, underemployment, and little or no change in net capacity;

2. new capital accumulation which forced competitive firms to lose market share and hence underutilize existing capital within the region;

3. new capital allocated to replacement of physically depreciated or technically obsolete assets; or

4. improvements in existing land and buildings or other allocation of capital to uses not affecting output capacity, such as pollution control.

Conversely, high values of X_{24} over time for an industry would indicate shifts in the theoretical production function and increments to net capacity. Because X_{24} represents current period capacity movements, it would be interesting to examine any possible correlation between it and growth of employment in an industry within Michigan as measured by relative first differences in employment. By this inductive process, high positive correlation would tend to support the contention that employment growth is associated with increments to productive capacity in a regional industry.

The results for the sample are listed in Table XI. It is notable that each industry displayed a relationship significant at 99 per cent confidence levels, with the exception of Chemicals and Petroleum (95 per cent) whose production is least labor-intensive and therefore least sensitive in employment to changes in capacity.[12/]

Since the marginal productivity of capital is significantly related to employment growth within each state sector, X_{24} will be useful in explaining the variance in Michigan's share of national employment and output in each industry over time. This may now provide a more accurate perception of the

---

12/ Estimates of capital-labor ratios are shown in Appendix, Table II-A.

Table XI

ASSOCIATION BETWEEN MARGINAL PRODUCTIVITY OF CAPITAL AND CHANGES IN EMPLOYMENT

Michigan Industry	Correlation Coefficient $X_{24} \cdot X_{28}$
Food	.73
Paper	.87
Chemicals and Petroleum	.55
Primary Metals	.91
Fabricated Metals	.87
Nonelectrical Machinery	.87
Electrical Machinery	.76
Transportation Equipment	.88

mechanisms of growth vis à vis the investment process. Productive capacity clearly represents a constraining factor to regional economic advance.

Multiple regression techniques were used to test the assumptions advanced above for each of Michigan's major industrial sectors. It should be noted when examining the regression equations that independent variables were allowed to enter an equation at significance levels of greater than or equal to .90, with respect to computed t-values of the net coefficients. In cases where two or more independent variables were included, care was taken to exclude any which exhibited significant intercorrelation. Residuals of prediction were also examined visually for constancy.

Table XII lists each industry's results in standard linear form including coefficient of determination and the standard error of the regression equation. Preceding the table (for the convenience of the reader) is a definition of all variables which appear in the models (a more complete listing can be found in Appendix Table I-A.), and a graphical representation of the predictive performance of some of the equations is included in Figures 3-6.

RESULTS OF THE ANALYSIS

The object now will be to examine the results by industry and discuss what useful information might be derived from the analysis in each case. If models such as these are of any value, it is that they provide a clearer view of historical patterns and the effects certain factors might produce in the future if the observable system does not change appreciably.

The results for the food industry (equations 1 and 2) indicate that Michigan's share of national total capital spending has accounted for much of the variance in its share of employment. In this industry, the share of value added which is produced in Michigan is fitted significantly to the relative first differences in output per production man-hour and the share of capital expended in the previous year. Even though regional shares in the food industry are not subject to wide variation because of the nature of the products and their income inelasticity of demand, we can discern a relationship between growth and the ability to produce efficiently as well as the ability to attract or generate an increasing regional share of investment.

Table XII

MICHIGAN INTERINDUSTRIAL GROWTH MODELS

(1) Dependent Variables--measures of relative growth in employment and value added (1949-67).

$\hat{Y}_{52}$	52SHAREM	--	Michigan's share of national employment of production workers, expressed as a proportion, by sector.
$\hat{Y}_{69}$	69CSHAEM	--	Change in Michigan's share of employment ($\Delta \hat{Y}_{52}$) from preceding year.
$\hat{Y}_{51}$	51SHARVA	--	Michigan's share of national value added.
$\hat{Y}_{68}$	68CHARV	--	Change in share of value added ($\Delta \hat{Y}_{51}$).

(2) Independent Variables--measures of labor productivity, extent of capital expenditure (relative), capital productivity, and wages.

X_o	TIME PT.	--	Time adjustment where 1949 = 0, ..., 1967 = 19.
X_{24}	24MARCAP	--	Estimated marginal productivity of capital, measured as the ratio of change in real value added to real new or incremental capital expenditures, by sector.
X_{33}	33RCPROD	--	Relative change in real value added per production man-hour.
X_{34}	34RCREWG	--	Relative change in Michigan's real wage rate, production workers.
X_{40}	40RCWGPD	--	Relative change in real value added per real dollar of wages to production workers.
X_{53}	53SHARCP	--	Michigan's share of national total new or incremental capital expenditures on plant and equipment.

(Continued)

Table XII--Continued

MICHIGAN INTERINDUSTRIAL GROWTH MODELS

$X_{53\ (t-1)}$		--	Previous year's capital expenditures (X_{53} lagged one year)
X_{64}	64RCNPRD	--	Relative change in national average real value added per production worker man-hour.
X_{70}	70CSHCPT	--	Change in Michigan's share of capital expenditures (ΔX_{53}).
$X_{70\ (t-1)}$		--	Previous year's change in share of capital, (X_{70} lagged one year).

(Continued)

Table XII--Continued

RESULTS OF REGRESSION ANALYSIS

Equation	Industry	Relationship	R^2	Std. Error
(1)	Food	$\hat{Y}_{52} = .033 + .079X_{53} - .002X_0$ (1.90) (-5.21)	.81	.0006
(2)		$\hat{Y}_{68} = -.002 + .031X_{33} + .124X_{70\,(t-1)}$ (3.07) (1.66)	.55	.0010
(3)	Paper	$\hat{Y}_{69} = -.003 + .004X_{24} + .023X_{33}$ (6.39) (2.60)	.80	.002
(4)		$\hat{Y}_{68} = -.003 + .004X_{24}$ (7.28)	.82	.001
(5)	Chemicals	$\hat{Y}_{69} = .0002 + .001X_{24} + .037X_{70}$ (4.53) (1.61)	.71	.001
(6)		$\hat{Y}_{51} = .046 + .023X_{33} - .0005X_0$ (5.26) (-6.55)	.82	.001

(Continued)

Table XII--Continued

RESULTS OF REGRESSION ANALYSIS

Equation	Industry	Relationship	R^2	Std. Error
(7)	Primary Metals	$\hat{Y}_{69} = .002 + .001X_{24} + .03X_{70}$ (4.53) (1.67)	.72	.001
(8)		$*\hat{Y}_{51} = .062 + .159X_{53\,(t-1)} + .002X_{24}$ (4.07) (4.76)	.82	.003
(9)	Fabricated Metals	$*\hat{Y}_{52} = .069 + .163X_{53\,(t-1)}$ (3.76)	.56	.006
(10)		$*\hat{Y}_{51} = .075 + .192X_{53\,(t-1)}$ (3.33)	.50	.009
(11)	Nonelectrical Machinery	$\hat{Y}_{69} = .0005 + .0006X_{24} - .029X_{64}$ (3.36) (-2.34)	.63	.002
(12)		$\hat{Y}_{68} = .002 + .110X_{40} - .081X_{64}$ (4.12) (-2.82)	.68	.006

(Continued)

Table XII--Continued

RESULTS OF REGRESSION ANALYSIS

Equation	Industry	Relationship	R^2	Std. Error
(13)	Electrical Machinery	$\hat{Y}_{69} = -.0009 + .0004X_{24} + .033X_{34}$ (4.40) (3.45)	.76	.0009
(14)		$\hat{Y}_{68} = -.0017 + .0008X_{24}$ (7.55)	.85	.001
(15)	Transportation Equipment	$*\hat{Y}_{52} = .131 + .122X_{33} + .113X_{53\,(t-1)} + .133X_{53}$ (1.73) (2.59) (3.17)	.83	.01
(16)		$*\hat{Y}_{51} = .111 + .284X_{33} + .139X_{53\,(t-1)} + .247X_{53}$ (1.84) (1.67) (2.70)	.73	.022
(17)		$\hat{Y}_{68} = -.020 + .624X_{33} - .289X_{64}$ (4.22) (-2.70)	.70	.026

*Time as an independent variable was not significant and did not meet the criterion for inclusion in the stepwise regression equation.

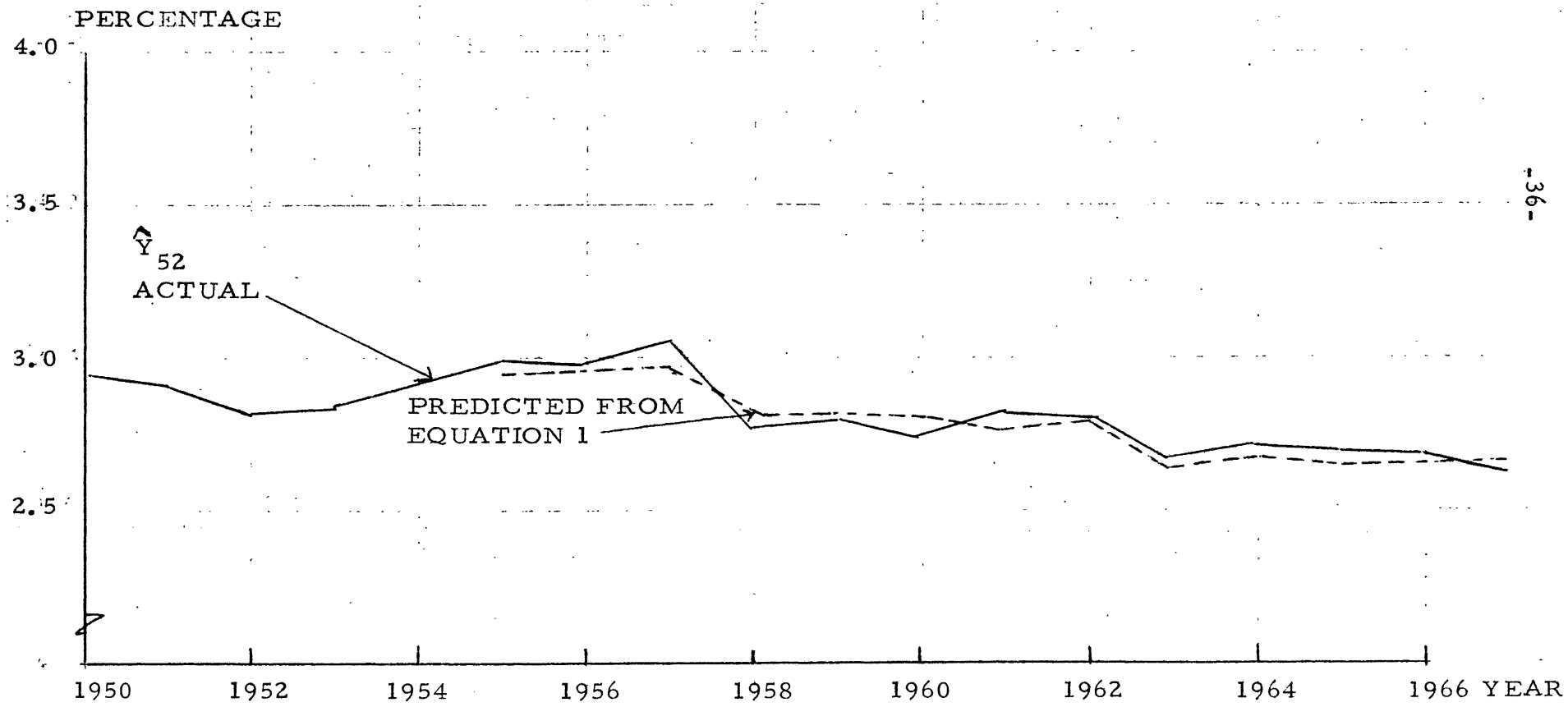

Figure 3. ACTUAL AND PREDICTED MICHIGAN SHARE OF NATIONAL EMPLOYMENT OF PRODUCTION WORKERS, SIC 20 - FOOD PRODUCTS (1950-67)

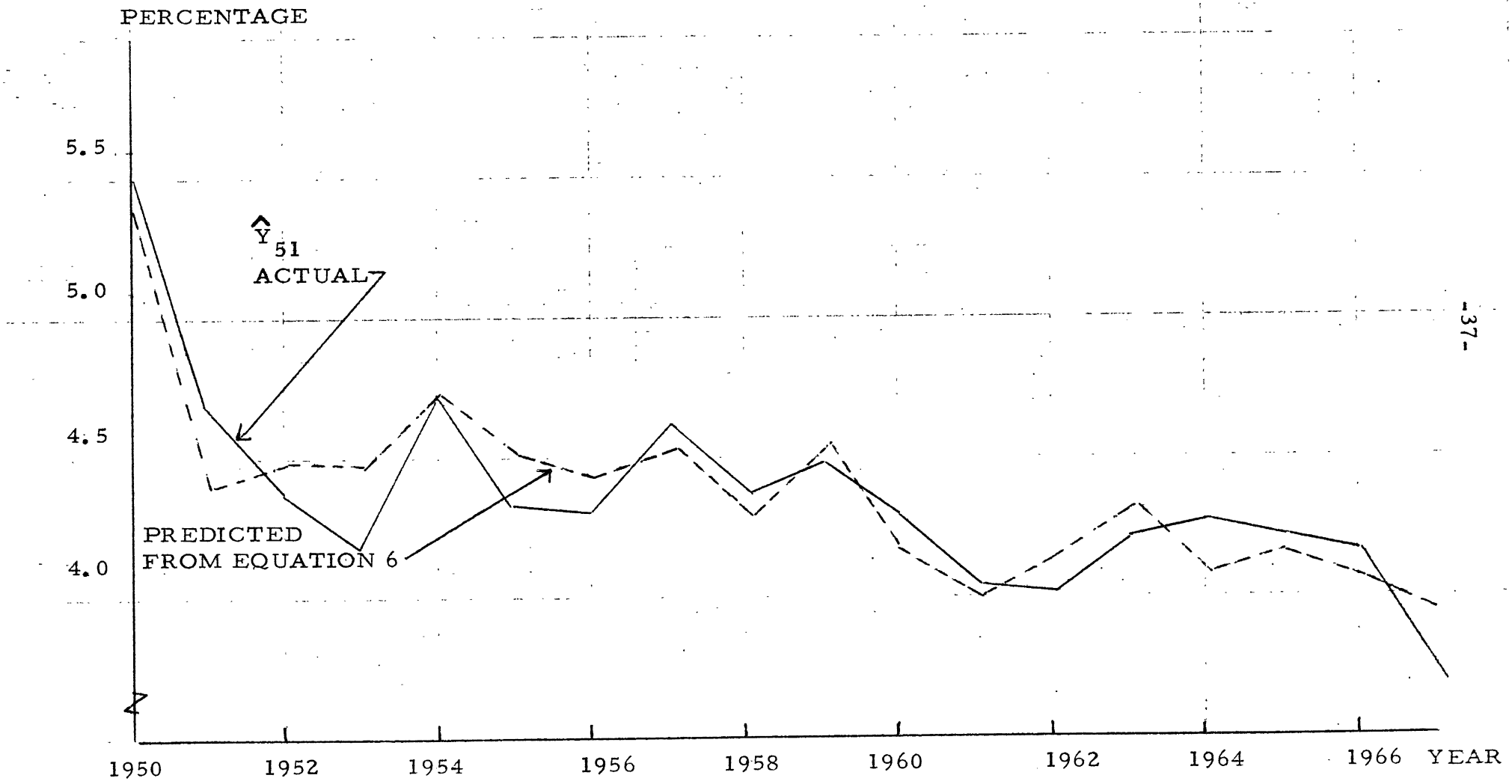

Figure 4. ACTUAL AND PREDICTED MICHIGAN SHARE OF NATIONAL VALUE ADDED BY MANUFACTURE, SIC 28 - CHEMICALS (1950-67)

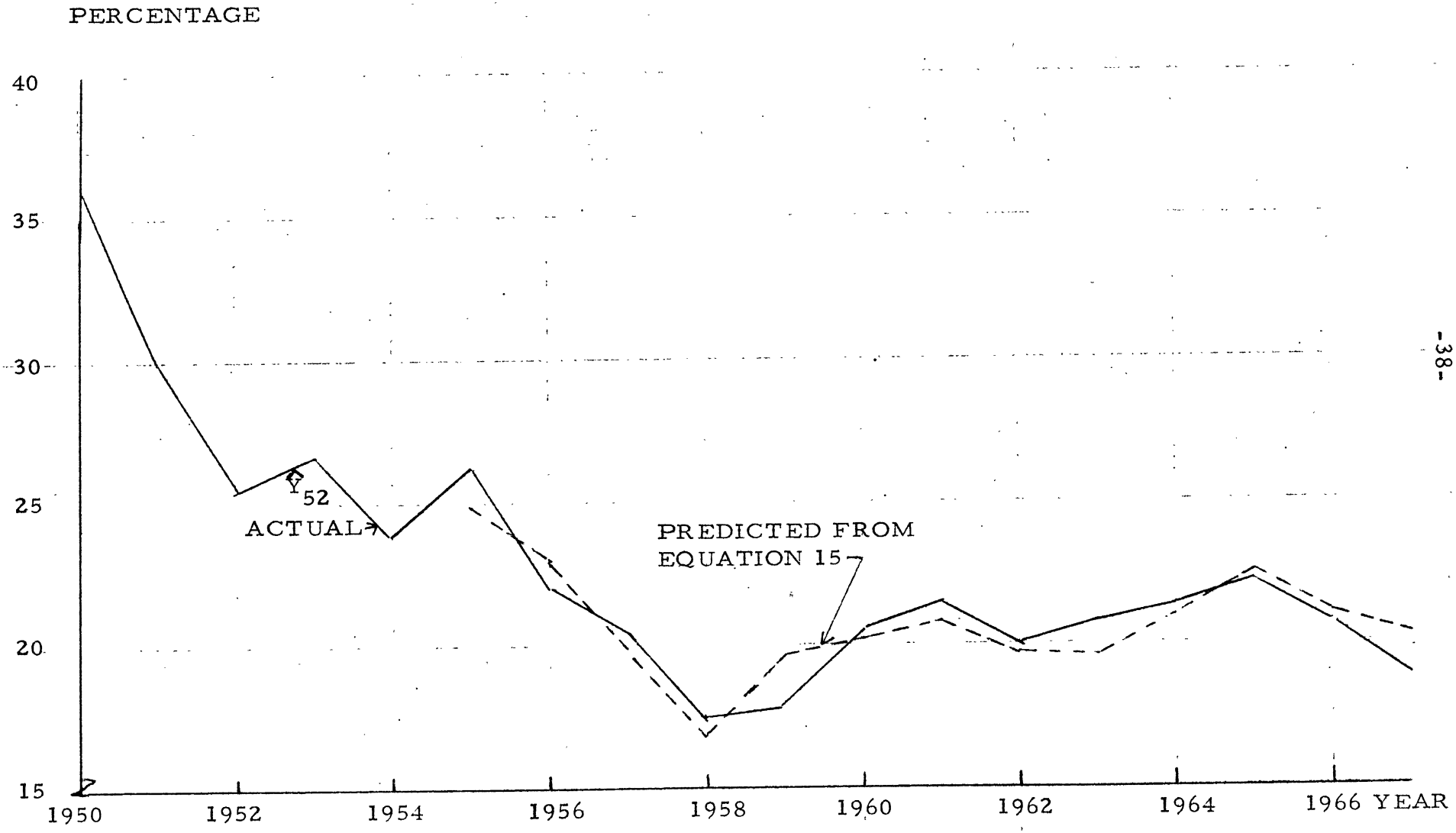

Figure 5. ACTUAL AND PREDICTED MICHIGAN SHARE OF NATIONAL EMPLOYMENT OF PRODUCTION WORKERS, SIC 37 - TRANSPORTATION EQUIPMENT MANUFACTURING (1949-1967)

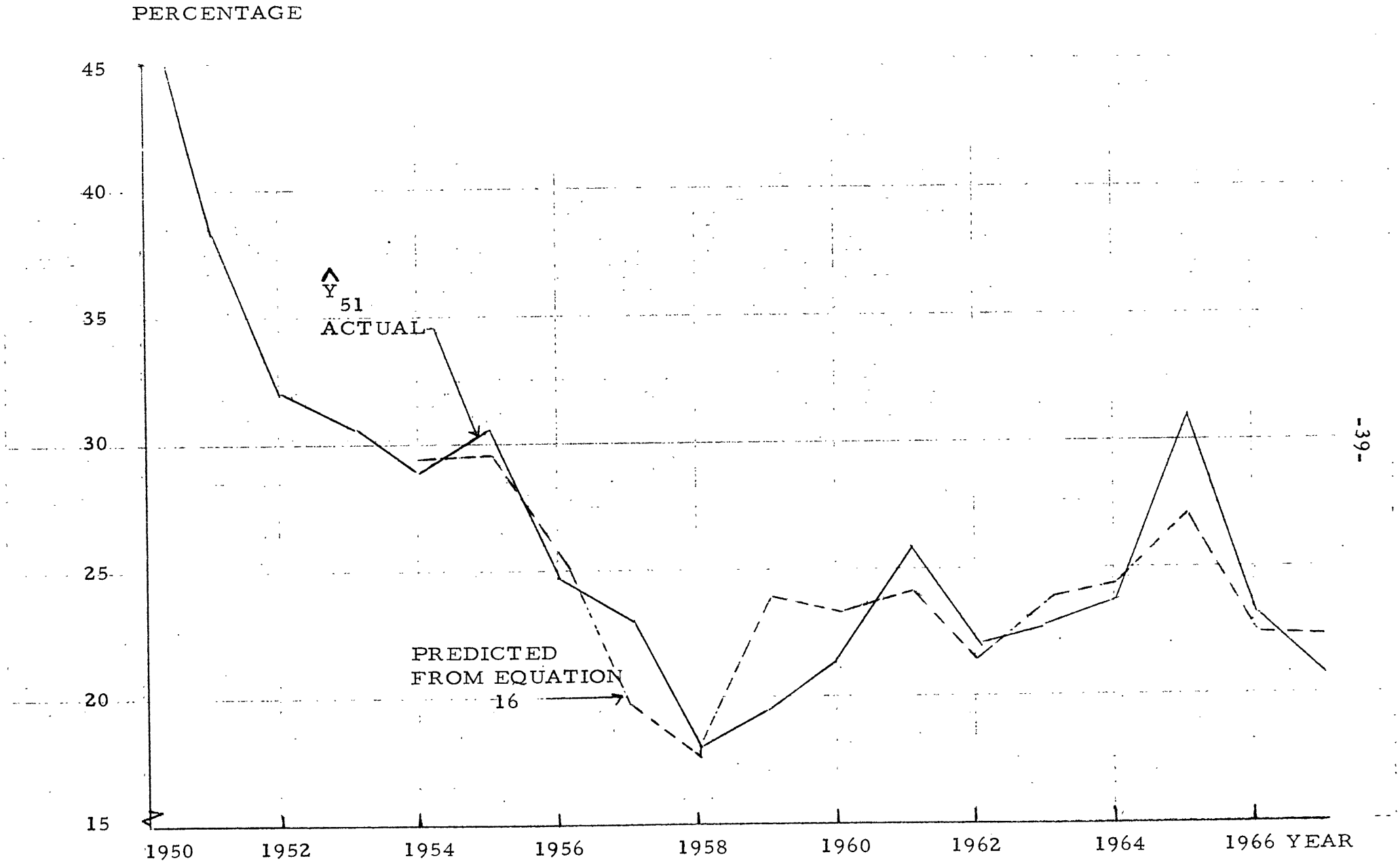

Figure 6. ACTUAL AND PREDICTED MICHIGAN SHARE OF NATIONAL VALUE ADDED BY MANUFACTURE, SIC 37 - TRANSPORTATION EQUIPMENT MANUFACTURING (1950-67)

The slowing rate of growth in Michigan's paper industry can be attributed statistically to decreasing or diminishing values for the analytical variable we have called marginal productivity of capital (X_{24}). These models, in terms of changes in state share, depict a regional industry whose slower-than-average growth may be associated with nonexpansionary allocation of capital caused by underutilization or replacement of assets. Equation 3 also includes productivity growth (X_{33}) as an independent variable,and the positive coefficient would point out the critical importance of productive efficiency as regions compete for job formation opportunities.

Changes in Michigan's share of employment in the petroleum and chemicals sector (equation 5) are also significantly explained by X_{24}, as well as the change in share of capital (X_{70}). Equation 6 would imply that growth in output per man-hour (with the influence of time removed) is the prime explanatory element in our model of value-added share. In this industry more than the others, growth in labor productivity would seemingly reflect the efficiency of the combination of all input factors, including new product research, production technology and supplies of intermediate materials. The tasks associated with human input are believed not as important to the overall performance of this industry as they might well be in others.

Equations 7 and 8 reflect observable patterns in the primary metals industry in Michigan. Increments to share of employment are positively associated with increments to share of capital expenditures and the extent

to which total annual investment adds to net capacity. Moreover, the previous year's share of capital and the marginal productivity of capital combine to explain 82 per cent of the variance in Michigan's proportion of total value added.

Lagged share of capital is the only independent variable significantly related to Michigan's share of output and employment in the fabricated metals sector (equations 9 and 10). This would indicate that this industry is quite homogenous across regions with respect to internal factors affecting growth. The allocation of annual capital expenditures to Michigan would enhance its ability to produce output, given exogenous influences which include the type of end-product to which fabricated metal products are directed, the cost of distribution, and the type of supplier contract which prevails in the region.

In nonelectrical machinery manufacturing, the influence of differential growth rates in regional productivity can be discerned. In 1971, the estimated average output per man-hour for the nation as a whole in this industry was $3.98 greater than the corresponding figure within Michigan. This comparison provides a startling contrast with the situation in 1950, when Michigan's labor force was nearly three times more productive than the national average!

As can be expected, Michigan's share of industrial resources has declined with its productivity position. Annual growth in the national average output per man-hour is negatively associated with increments to Michigan's share of value added and employment. The capacity increment (X_{24}) also acts

to influence employment growth, while growth in Michigan's output per wage-dollar positively influences changes in share of value added. As the models indicate, productive resources flow to the most efficient regions, and in this particular case Michigan's loss is evident.

The expansionary tendencies in the electrical machinery industry in Michigan would lead one to expect that net capacity growth (X_{24}) would be a highly potent explanatory variable. The accumulation of "chunks" of new capacity should be the prime mechanism for regional growth. The regression does seem to verify this notion, as changes in Michigan's share of employment and value added are fitted to X_{24} with coefficients displaying small standard error. The reader may view equation 13 with curiosity about the inclusion of the positive influence of wage rate growth as a predictor of employment share. This could be attributed to the fact that demand for workers with these types of skill is high relative to supply, as might be expected in the fastest growing industry.

In the long-standing transportation equipment industry, three equations are presented for informational value (equations 15-17). The composition of SIC 37 is of course more heavily dominated by automobile-manufacturing in Michigan than in other areas. However, this disproportionality has been essentially constant over the sample period and would not seem to bias the regression results. The explanation of the significant decline in share of output and employment originating in Michigan can be put forth by three variables: the relative change in real value added per production man-hour

(X_{33}), Michigan's share of national total new or incremental expenditures on plant and equipment (X_{53}), and the previous year's capital expenditures ($X_{53\ (t-1)}$). This reflects the obvious regional decentralization of resource allocation by the major auto producers to newer, more productive plants outside of Michigan as a likely reaction to upward cost-push pressures in manufacturing and distribution.

It is hoped that as these models are examined certain salient considerations are clarified. The real objective of modeling is to break down a complex system into one that is somewhat more manageable conceptually. Information from efforts like these could provide a starting point for further regionally based research. In addition, such efforts may help to redirect the emphasis of governmental policy on industrial development, arming the governmental representative with higher quality information for improving business-government relations in a region. The nature of these business-government relationships, in turn, clearly affects the socioeconomic climate for all inhabitants of a region.

AGING CAPITAL AND STRUCTURAL UNEMPLOYMENT-- IMPEDIMENTS TO REGIONAL ECONOMIC GROWTH

The preceeding statistical analyses allow us to draw certain inferences about the nature of industrial growth in Michigan. The ability to maintain a substantial growth in output per man-hour for the state's labor force is essential to regional competitiveness. The historical patterns also tell us

that stimulation of capital spending by firms within the state is of prime importance and this investment process is essential to the creation of additional productive capacity necessary to support higher levels of employment.

Michigan's industrial mix is dominated by mature sectors. The problems associated with this condition are quite evident. The traditional manufacturing sectors now face nearly saturated markets and mounting environmental constraints. The key to future success for these industries is the ability to develop innovative cost-reducing technology and, in the process,to force out less efficient entities.[13/] However, this increasing technological emphasis has an impact on the demand for industrial labor. In maturing regions, employment growth is influenced by the fact that the creation of new jobs will require higher levels of skill. And characteristically strong labor union influences will maintain the job security of existing employees and tend to resist technological displacement of semi-skilled workers. In such regions, potential job openings of this type, therefore, tend to be filled internally by reassignment or retraining.

The new labor market seeks a different type of worker--one who is highly skilled and possesses the aptitude to adapt to changing technological requirements. It seems clear, then, that for a region to be industrially

---

13/ An interesting discussion of regional economic maturity and its ramifications (quite analagous to Michigan) can be found in "New England: What Replaces the Old Industry?" Business Week, Aug. 4, 1973, pp. 36-45.

competitive its employed labor force must meet these higher structural requirements which allow new capital and human resources to be combined most efficiently. An earlier study of unemployment in Michigan based on the 1970 census survey data found that structural characteristics of county labor markets accounted for much of the differences in measured unemployment rates across the state. These influences included educational attainment, skill mix, and locational mobility of employment.[14/]

As the results of the regression analysis indicate, the quality and quantity of Michigan's stock of capital and its corresponding stimulus to capacity expansion have wide-ranging effects on economic growth. Annual survey data, as mentioned earlier, do not provide direct measures of net capital flows. Therefore, new capital expenditures were used for the analysis as an estimate of capital expansion (net of price level changes). In order to get a feel for the true rate at which capital stocks are expanding, one would need to know the rate at which old or existing assets are being replaced in the production function.

As any economist, accountant, or production foreman knows, machinery, buildings, fixtures,and plumbing have only a finite useful life. Our systems of financial accounting may never accurately reflect true asset flows. A ten-year-old machine with a net book value of $20,000 may in fact be only

---

14/ Gary Potts, "Regional Unemployment and Female Labor Force Participation in Michigan," (unpublished paper, University of Michigan, 1973).

half as productive as a new machine worth the same amount. Because the largest industrial sectors in Michigan are mature in comparison with newer technology-based industries, it is quite conceivable that a dollar of capital expenditure in Michigan would not provide the same expansionary effect as would a dollar invested elsewhere.

In the East North Central region, a striking contrast in capital expansion rates exists. A 1969-70 survey of net book value of assets by region can be used to compare with total new capital expenditures for corresponding years to determine the proportion of these expenditures which actually went to capital expansion, and what proportion went to replacement of old or obsolete capital equipment.

Table XIII represents the levels of capital stocks at the end of 1969 and 1970. The net change over this period can be compared to total capital spending, as shown in Tables XIV and XV. An examination of these comparative flows indicates that Michigan is experiencing a critically high rate of asset replacement. Again, a growing stock of capital is essential to growth in productive capacity within the state, which in turn provides the prime stimulus to the formation of new jobs.

This information provides considerable insight into the nature of industrial development problems facing the state. The formulation of policies to deal with problems of structural unemployment and slowing capital accumulation is essential to economically mature regions such as Michigan. The consequences

Table XIII

NET BOOK VALUE OF ASSETS--END OF YEARS
1969 AND 1970
(in Millions)

	1969	1970	1969-70 Net Change
U.S.	$249,243.9	$266,265.8	$ 23,021.9
Michigan	16,134.9	16,834.6	699.7
Ohio	21,155.2	22,779.8	1,624.6
Illinois	17,181.5	18,570.6	1,389.1
Indiana	13,182.7	13,829.0	646.3
Wisconsin	5,585.1	6,006.9	421.8
ENC Total	73,239.4	78,020.9	4,791.5

Source: U.S., Bureau of the Census, Annual Survey of Manufacturers: 1970, Book Value of Fixed Assets and Rental Payments for Buildings and Equipment (Washington, D.C.: U.S. Government Printing Office, 1972).

Table XIV

NEW CAPITAL EXPENDITURES, EAST NORTH CENTRAL REGION, 1969-70
(in Millions)

Area	1969	1970
Michigan	$1,371.6	$1,300.7
Ohio	1,975.1	1,705.7
Illinois	1,492.5	1,515.4
Indiana	1,168.4	1,016.2
Wisconsin	473.2	468.1
ENC Total	6,480.8	6,006.1

Source: U.S., Bureau of the Census, Annual Survey of Manufacturers, 1971 East North Central Division (Washington, D.C.: U.S. Government Printing Office).

Table XV

PERCENTAGE OF NEW CAPITAL ALLOCATED TO REPLACEMENT, 1970, EAST NORTH CENTRAL REGION

	1969-70 Change in Net Book Value of Depreciable Assets	1970 New Capital Expended on Plant and Equipment	1970 Percentage of New Capital Allocated to Replacement
Michigan	$ 699.7	$1,300.7	46.3
Indiana	646.3	1,016.2	36.6
Wisconsin	421.8	468.1	10.0
Illinois	1,389.1	1,515.4	7.7
Ohio	1,624.0	1,705.0	4.8
ENC Total	4,782.0	6,006.0	20.4

of environmental and fiscal policies must be evaluated in terms of these specific economic conditions and the trade-offs which likely exist.

CONCLUSIONS AND RECOMMENDATIONS

Within eight major two-digit industrial sectors in Michigan, the state's annual share of national employment and output can be statistically explained by various combinations of the following factors:

1. changes in productivity of the labor force,
2. the share of national capital expenditure applied to Michigan annually,
3. the estimated marginal productivity of capital expenditure.

As Michigan's industrial sectors have matured, reduced efficiency of productive inputs has diminished the ability of the state to sustain significant growth in its share of employment and output. As existing capital becomes obsolete, new technology and competitive forces produce the necessity of capital replacement, resulting in slower rates of capacity expansion. Concurrently, the rising technological requirements of new job formation demand a regional labor force of higher skill and aptitude in order to provide the most efficient combination of capital and labor.

Regional industrial development policies must take into consideration economic information such as is presented here. But a set of growth-oriented policies must also fit nicely into the overall social and environmental posture

of state government. Given the conclusions of this study, it is important to ask what regional policy tools can be implemented in the best interests of the state. But before specific suggestions are set forth, perhaps it is best to outline the general tactical means by which the state can move towards an objective of full employment through industrial growth. Very simply, the strategy should be to:

1. improve the productivity profile of Michigan labor, and

2. create as much incentive as possible to capital spending within the state.

In the general area of productivity, state administrators must cooperate with private industry to gain a mutual understanding of the barriers to more rapid growth in productivity. It must be clear what specific factors have caused weakening or improvement in the competitive strength of the state's industrial sectors--whether such factors be the availability of funds necessary for research or for the implementation of more efficient technology, or other factors more closely linked to the characteristics of the regional labor force (labor relations, supply of adequately trained workers, etc.). A closer accounting should be made within the state's industry as to the effects on productivity performance of research and development expenditures and of expenditures on human resources. These activities would entail industry-oriented seminars and cooperative research programs sponsored by the state and aided by the academic community.

Taking into consideration such factors as market and intermediate supply access, more clearly defined three- and four-digit SIC sectors could be identified as to productivity potential and would be logical targets for specific incentive measures.

As for the encouragement of capital spending, the implications are that a more potent service sector must be developed within the state to facilitate the flow of funds from savings to investment. Fiscal policies can provide only a finite impetus to investment. A larger financial services community--commercial and investment banking, brokerage houses, suppliers of venture capital,and other fiduciary and intermediary institutions are needed to support any such effort.

Specific policies could include liberalizing small business loans, subsidizing bank interest rates to state industry in order to alleviate the severe cyclical risk of doing business in Michigan, increasing research funds to state industry, and the establishment of tax benefits for capacity-expanding investment.

Clearly, Michigan has the potential and resources to support a thriving industrial sector in the future. The state's degree of success in providing for the economic prosperity of its population will depend upon policies based on a clear understanding of all factors affecting regional industrial growth, including the few presented here, and on the ability to reduce any obstables to growth which can be identified over time.

BIBLIOGRAPHY AND RELATED READINGS

Bretzfelder, R.B. "Sensitivity of State and Regional Income to National Business Cycles." U.S. Department of Commerce. Survey of Current Business, April 1973, pp. 22-35.

Denison, E.F. "Some Major Issues in Productivity Analysis: An Examination of Estimates by Jorgenson and Gilriches." U.S. Department of Commerce. Survey of Current Business, May 1969, Part II.

Domar, E.D. Essays in the Theory of Economic Growth. New York: Oxford University Press, 1957.

_____., "On Total Productivity and All That." Journal of Political Economy, December 1962, pp. 597-608.

Draper, N., and Smith, H. Applied Regression Analysis. New York: Wiley and Sons, Inc., 1967.

Fuchs, V., and Wilburn, J. Productivity Differences within the Service Sector. New York: National Bureau of Economic Research, 1967.

Grayson, C.J., Jr. "How to Make Productivity Grow Faster." Business Week, July 14, 1973, pp. 15-16.

Kendrick, J.W. Productivity Trends in the United States. Princeton, N.J.: Princeton University Press, 1961.

_____. Postwar Productivity Trends in the United States. Princeton, N.J.: Princeton University Press, 1973.

Leabo, D.A. Basic Statistics. Homewood, Ill.: Richard J. Irwin, Inc., 1972.

Mansfield, E. The Economics of Technological Change. New York: Norton, 1968.

Mark, J.K. "Concepts and Measures of Productivity." In The Meaning and Measurement of Productivity. Edited by Herbert Stein. Washington, D.C.: U.S. Department of Labor, 1971.

Mueller, E., Wilken, A., and Wood, M. Locational Decisions and Industrial Mobility in Michigan 1961. Ann Arbor: Institute for Social Research, University of Michigan, 1961.

Perloff, H.S., and Dodds, V. How a Region Grows. New York: Committee for Economic Development, 1963.

Peterson, W.C. Income, Employment and Economic Growth. New York: Norton, 1967.

Salter, L. Productivity and Technological Change. London: Oxford University Press, 1965.

Schumpeter, J. Capitalism, Socialism and Democracy. New York: Harper and Row, 1950.

Sobotka, S. Profile of Michigan. New York: Free Press of Glencoe, 1963.

Solow, R. "Technical Change and the Aggregate Production Function." The Review of Economics and Statistics, August 1957, pp. 512-20.

Suits, D. Econometric Model of Michigan. Lansing, Mich.: Department of Economic Expansion, 1965.

_____.* "New England: What Replaces Old Industry?" Business Week, August 4, 1973, pp. 36-42.

U.S. Bureau of the Census. Annual Surveys of Manufacturers. Washington, D.C.: U.S. Government Printing Office, 1950-71.

_____. 1970: Book Value of Fixed Assets and Rental Payments for Buildings and Equipment. Washington, D.C.: U.S. Government Printing Office, 1972.

*No author given.

APPENDICES

Table I-A

DESCRIPTION OF VARIABLES

Variable	Definition
1YEAR	Year
2RAWVAL	Adjusted value added by industry, in millions of current dollars.
3DEFLATE	Price index proportion of current price level to that of 1967 for appropriate industry.
4EMPLOY	Total production workers employed, in thousands.
5MANHRS	Total production man-hours, in millions.
6TOTWAGE	Total wage payments to production workers in current dollars (millions).
7NEWCAPT	Annual capital expenditures in millions of current dollars.
8PURCHPR	Consumer price index purchasing power of the dollar relative to 1967 prices.
9REALVAL	Value added in 1967 dollars.
10GRATE	Average wage per man-hour in current dollars.
11LABPRD	Real output per man-hour.
12REALWG	Real wage rate in 1967 dollars.
13CEMPLY	Change in employment of production workers from previous year (in thousands).
14CMANHR	Abs. change in man-hours utilized from T-1.
15CPURCH	Abs. change in purchasing power of the dollar in index terms.
16CREVAL	Abs. change in real value added.

Continued

Table I-A--Continued

DESCRIPTION OF VARIABLES

Variable	Definition
17CWRATE	Abs. change in wage rate in current dollars.
18CPROD	Abs. change in real output per man-hour.
19CRWRE	Abs. change in real wage rate.
20REALCP	Real capital expenditures in 1967 dollars.
21WRKYR	Hours per man-year, in thousands.
22RTWAGE	Real total wage payments.
23WAGPRD	Real output per dollar of wage.
24MARCAP	Change in value added per dollar of new capital in real terms.
28RCEMPL	Relative change in total employment.
29RCMNHR	Relative change in man-hours utilized.
30RCPUR	Relative change in consumer purchasing power as measured by CPI.
31RCVALU	Relative change in real value added.
32RCWG	Relative change in current dollar wage rate.
33RCPROD	Relative change in output per man-hour in real terms.
34RCREWG	Relative change in real wage rate.
35RCTOWG	Relative change in total real wage payments.
43RCDEFL	Relative change in price deflator.

Continued

Table I-A--Continued

DESCRIPTION OF VARIABLES

Variable	Definition
44NAL	National total value added by industry in current dollars.
45NMH	National total man-hours utilized by industry.
46NEMP	National total employment of production workers.
47NTOWG	National total wages paid to production workers in current dollars.
48NCAPT	Total national capital expenditures in current dollars.
49NREVAL	National real value added, 1967 dollars.
50NPROD	National average real output per man-hour.
51SHARVA	State's share of national real value added.
52SHAREM	State's share of national employment.
53SHARCP	State's share of national capital expenditures.
55NWGRT	National average real wage rate.
56NWGPD	National value added per dollar of wage (1967 $).
62RCNEMP	Relative change in national employment of production workers.
63RCNVAL	Relative change in national value added.
64RCNPRD	Relative change in national average value added per man-hour (1967 $).
65RCNWG	Relative change in national wage rate.
66RCWGPD	Relative change in output per wage dollar.

Table I-A--Continued

DESCRIPTION OF VARIABLES

Variable	Definition
68CHARV	Change in state's share of value added, by industry.
69CSHAEM	Change in state's share of employment of production workers, by industry.
70CSHCPT	Change in state's share of capital expenditures, by industry.

Table II-A

U.S. ECONOMY
RELATIVE CAPITAL-LABOR PROPORTIONS

Industry	Book Value of Total Assets per Employee, End of 1968	Capital Intensity Ranking
Food	$ 13,165	5
Paper	25,872	3
Chemicals	35,202	1
Petroleum	96,504	
Primary Metals	28,897	2
Fabricated Metals	9,368	7
Nonelectrical Machinery	10,488	6
Electrical Machinery	6,804	8
Motor Vehicles	13,328	4

Source: U.S., Bureau of the Census, Annual Survey of Manufacturers, 1970: Book Value of Fixed Assets and Rental Payments for Building and Equipment, M (70) AS-7 (Washington, D.C.: U.S. Government Printing Office, 1972).