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THE USE OF INPUT/OUTPUT IN REGIONAL ANALYSIS: AN EXAMINATION OF ECONOMIC LINKAGES IN NORTHERN OHIO*

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With limited regional fiscal and professional economic development resources, it is important to focus these resources on programs which accomplish stated goals. A number of issues must be addressed in order to decide on an economic development strategy: 1) determination of the goals of a region, 2) the selection of industries to target for attention (or neglect), and 3) the selection of strategies or policies to apply to these selected industries (financial packaging, labor training, visitation committees etc.).

Our objective in this paper is to explore how input/output (I/O) analysis can be used to identify or target those industries which are most important to the economic growth or decline of a region. Through the complete specification of economic relationships or linkages among the sectors of a region, we can examine the impact of a change in demand for the output of a sector on that sector, and in addition on all other sectors of the regional economy. The total impact of a given change depends upon the number and size of the linkages to other sectors. Large sectors which have strong linkages are identified as the important sectors.

We then use employment data to distinguish between those important industries which are likely candidates for sectoral growth strategies vs. those which have declining employment and a strategy to offset this decline (such as job retraining for an alternative growing industry) is needed. The analysis of which explicit strategy or policy for any given industry is beyond the scope of this study.

We develop and analyze an I/O model for the historically heavy industry belt of northern Ohio. This region is representative of heavy industry regions in the Great Lakes area of the midwest and contains a relatively large portion of the Great Lakes heavy industry activity and of the Ohio economy. Northern Ohio

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contains some of the most industrailized and urbanized counties in Ohio and in the U.S. In 1958, Ohio was surpassed only by New York, California and Illinois in manufacturing employment. Five of Ohio's ten largest manufacturing counties were located in the 17-county study region of northern Ohio, with Cuyahoga having the largest (241,000) manufacturing employment.

Over the past 20 years, economic change accompanied by new technologies and new sources of raw materials has altered the employment potential of northern Ohio. Between 1960 and 1980, manufacturing employment declined by 7.5 percent in this region to 550,653 while it increased by 0.8 percent in Ohio, by 5.7 percent in the East North Central or Great Lakes states, and by 24 percent in the U.S. [13].

The I/O model is developed for a 17-county region which contains the major industrial counties of northern Ohio: Ashtabula, Cuyahoga, Erie, Geauga, Huron, Lake, Lorain, Lucas, Mahoning, Medina, Ottawa, Portage, Sandusky, Seneca, Summit, Trumbull and Wood counties. In 1978, this 17-county region generated output of $150 billion, income of $19 billion, and employment of 1.7 million man-years. Over 46 percent of the people employed in Ohio were employed in this region.

Methodology

An I/O model is a set of linear equations representing total outputs of different sectors within a region as the sum of intermediate demand by endogenous intermediate sectors and final demand by the household, government and export sectors. Three fundamental assumptions of the model are fixed coefficient production functions, constant relative prices of inputs and outputs, and production of homogeneous output in each sector, e.g., see Chiang [3] and Leontief [9,10]. It is also implicitly assumed that each sector maximizes its total output subject to constraints that total output less intermediate inputs is greater than or equal to available resources (labor, capital, and imports).

All I/O models consist of three parts: a flow table, a technical coefficients matrix and an interdependence coefficients matrix. These matrices show the economic linkages among the producing (intermediate) sectors of a regional economy. The flow table shows the final demand for goods and services, and the intermediate sector transactions required to satisfy final demand. Each column of the technical coefficients matrix shows the direct value of input from each sector required to produce one dollar of output in a given sector. Each column of the interdependence coefficients matrix shows the total value of input from each sector required to provide one dollar of output to final demand. These total (direct plus indirect) linkages among intermediate sectors, measured by the interdependence coefficients, are summed down the column for each sector to provide a summary measure of the backward linkage called the impact coefficient or multiplier.[1/] We use three multipliers in this paper: output,

1. Because an I/O model is demand driven, we limit our analysis to backward linkages. Definitions of forward linkages which measure sales to other endo-

income, and employment. The output multiplier is the total change in output of the region which results from a one-unit change in final demand for the output of a sector, or the column sum of the interdependence coefficients matrix for that sector. The income (employment) multiplier is the total change in income (employment) which results from a one-unit change in income (employment) where the income (employment) change is generated by a change in final demand. It is the column sum of the interdependence coefficients weighted by average sectoral income (employment) divided by average income (employment) in that sector.

In this study, we use a 43-sector, open, single region, static I/O model. The 1972 U.S. National I/O model updated to 1978 prices but not technology by Kakish [6] is used to derive 40 sectors of the regional model. The highly disaggregated 365 sector model is aggregated to reflect the size and structure of the region's economy using the supply-demand pool approach (the commodity balance equations).[2/] Data for two sectors (marina and boat sales, and charter fishing) are developed from primary data surveys, while data for a third sector (commercial fishing) is adapted from King and Shellhammer [8].[3/] Final demand is composed of a single comsumption sector and exports, while primary inputs are compsed of value added (labor and capital) and imports. All final demand and primary input sectors are treated as exogenous sectors.[4/]

High impact sectors are defined as large sectors which have high multipliers. We identify the high impact sectors of northern Ohio in three steps. First, the largest sectors and the sectors with the highest output, income and employment multipliers are identified. While size of sector is in part a definitional issue, an indicator of the importance of industries is needed to determine the expected effects of sectoral changes on the regional economy. In this study, we attempt to aggregate the 365 national sectors into regional

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genous industries also exist. These definitions vary depending upon what induces the sales; their conceptual justification is not as direct as for backward linkages. See Cella [2] for a discussion of forward and backward linkages.

2. The computer program for the development of the regional input-output model and the aggregation of the 365 sectors into 40 sectors is presented in Kakish and Morse [7]. At the time this study was undertaken, 1978 was the most recent year for which all data were available.

3. These three sectors were defined to accomplish objectives addressed in Apraku [1] and Hushak, Morse and Apraku [5]. To maintain internal consistency, marina and boat sales and charter fishing transactions are removed from the recreation and amusement sector while commercial fishing transactions are deducted from forestry products (which includes commercial fishing in the national model).

4. A complete specification of the model is found in Hushak, Morse and Apraku [5]. A list of the endogenous sectors included in the model is found in Appendix Tables A and B.

sectors of reasonable size and of relatively homogeneous industries. The largest sectors in our model tend to be aggregates of relatively small numbers of disaggregated sectors from the national model which have large employment in the region, especially the manufacturing sectors. Several service oriented sectors could be usefully disaggregated to lower levels, but we are limited by the national model. Five sectors (commercial fishing, charter fishing, marina and boat sales, mineral extraction and water transportation) which were disaggregated from other sectors to fulfill objectives of Hushak, Morse, and Apraku [5] have no bearing on the ranking of the large sectors, but do enter the multiplier rankings.

Second, those sectors which rank high on these criteria are defined as the high impact sectors, i.e., they have the potential of generating the largest impacts in the region. However, it is important to know whether these sectors are growing or declining in the region. In the third step we separate these high impact sectors into those sectors which have shown increasing vs. decreasing regional employment over the 1960-80 period.[5/] Those sectors which are growing are considered to be capable of generating further growth in the region. Those which are declining are problem sectors where policy decisions need to be made about whether to attempt to stop the decline or to offset the decline by stimulating growth in other sectors.

Results

The choice of how many sectors to consider as large or as having large multipliers is arbitrary. The purpose of selecting sectors is to reduce the number of sectors which must be considered. In this paper we chose 15 as the cut-off for illustrative purposes. The largest 10 sectors (25 percent) seems too limiting while 20 sectors (50 percent) seems too inclusive. With the exception of employment where the 16th ranked sector is only about 50 percent as large as the 15th ranked sector, the arrays by size and multipliers decline in relatively uniform amounts when ranked by size of sector or multiplier. However, those sectors at the margin (ranked 16th or 17th) are commented upon where they overlap with sectors in the top 15 on other criteria. The size and multiplier variables for all sectors are provided in Appendix Tables A and B.

To select the sectors which appear in Table 1, the 15 largest sectors for each of the three size criteria (output, income and employment) are listed. From these lists, it is found that 12 sectors are common to all three lists; this comprises the first group of sectors in Table 1, i.e., construction, primary iron and steel manufacturing, etc. An additional four sectors appear on two lists, while one sector (Electricity, Gas, and Sanitary Services) appears only once. If the 16th and 17th ranked sectors were added, crops, chemicals and allied products, and retail would move to the three of three section of Table 1.

5. This is a very crude way of predicting future growth or decline of economic sectors. While sectoral growth and decline is an important regional issue which deserves careful analysis, that research is beyond the scope of this study.

TABLE 1
Employment and Employment Multipliers for the Largest Output, Income and Employment Sectors, 17-County Region, 1978

Ranked in Top 15 in	Employment Man-Years	Employment Multiplier
Three of Three		
Construction	66,767	2.21
Rubber & Leather Products	48,711	1.83
Primary Iron & Steel Manufacturing	67,128	2.15
Heating, Plumbing & Fabricated Metals	54,215	1.92
Miscellaneous Machinery	64,933	1.88
Electric & Electronic Equipment	57,990	1.85
Motor Vehicle Equipment	87,957	3.12
Wholesale	95,838	1.47
Finance & Insurance	60,693	2.58
Eating & Drinking Establishments	81,385	1.42
Health Services	106,470	2.11
Miscellaneous Services	326,003	1.31
Two of Three		
Crops*	45,347	1.51
Chemicals & Allied Products+	21,875	3.47
Non-Water Transportation†	44,261	1.54
Retail†	194,979	1.09
One of Three		
Electricity, Gas & Sanitary§	17,648	2.50
Regional Economy	1,714,140	1.90

* Large output and employment.
\+ Large output and income.
† Large employment and income.
§ Large output.

The employment and employment multipliers for each sector are also presented in Table 1. Comparable information on output and income is included in Appendix Tables A and B. The 17 sectors listed in Table 1 account for 84 percent of output and employment in the region, and 81 percent of income. These sectors appear to dominate the regional economy. The mean output per man-year of employment is $86,700 as compared to $87,300 for the region and the mean income per man-year is $10,700 as compared to $11,100 for the region.

TABLE 2
Employment and Employment Multipliers for the 15 Largest Multiplier Sectors, 17-County Region, 1978

Ranked in Top 15 in	Employment Man-Years	Employment Multiplier
Three of Three		
Food & Kindred Products	17,179	3.00
Textiles	14,925	2.00
Primary Nonferrous Metals	21,099	2.31
Heating, Plumbing & Fabricated Metals	54,215	1.92
Motor Vehicle Equipment	87,957	3.12
Water Transportation	2,324	2.09
Finance & Insurance	60,693	2.58
Charter Fishing	42	2.83
Two of Three		
Livestock*	4,729	1.74
Furniture & Fixtures*	6,277	1.69
Chemicals & Allied Products+	21,875	3.47
Boat-Ship Building & Repair*	2,518	1.55
Other Manufacturing*	6,259	1.71
Auto Repair Services†	10,604	2.62
Marina & Boat Sales*	3,790	1.53
One of Three		
Other Mining§	970	2.84
Construction§	66,767	2.21
Paper & Allied Products¶	9,598	1.84
Primary Iron & Steel Manufacturing§	67,128	2.15
Electric & Electronic Equipment**	57,990	1.85
Electricity, Gas & Sanitary§	17,648	2.50
Health Services§	106,470	2.11

* Large output and income multipliers.
\+ Large income and employment multipliers.
† Large output and employment multipliers.
§ Large employment multiplier.
¶ Large income multiplier.
** Large output multilplier.

Table 2 is developed similarly to Table 1, except that the largest output, income and employment *multipliers* are used to select the top 15 sectors. A total of 22 sectors appears in Table 2. Eight of these sectors appear on all

three lists of top 15 sectors as ranked by the three multipliers. Seven sectors appear on two lists and seven on only one. Five of the seven sectors which appear only once have high employment multipliers. Among the 16th and 17th ranked sectors are rubber and leather products, chemicals and allied products, electric and electronic equipment and miscellaneous machinery.

The 22 sectors in Table 2 account for 62 percent of the output, 51 percent of the income and 37 percent of the employment. The mean output per man-year of employment is $145,300 for the sectors in Table 2 as compared to $86,700 in Table 1. Similarly, the mean income man-year of employment is $15,300 as compared to $10,700 in Table 1. While the sectors in Table 2 are smaller than those in Table 1, they are more capital intensive and higher paying.

The second step is to use both the size and the multiplier criteria to sort out the highest impact sectors in the region. These two criteria are appropriate because: (1) a small change in a large sector can easily result in a larger regional impact than a large change in a small sector and (2) a larger multiplier means a larger regional impact per unit change in final demand for the output of a sector.

Three sectors clearly stand out as high impact sectors because they appear in the top 15 sectors on both criteria: (1) heating, plumbing and fabricated metals, (2) motor vehicle equipment, and (3) finance and insurance. These are relatively large sectors of output, income, and employment which have relatively large output, income, and employment multipliers.

A total of six other sectors appears in both tables. Chemicals and allied products rank on two size criteria (output and income) and two multipliers (income and employment). Construction, primary iron and steel, electric and electronic equipment, and health services are large sectors which rank on only one multiplier criteria. Electricity, gas and sanitary services ranks on one criteria in each table. In addition, rubber and leather products and miscellaneous machinery are large sectors which have two and one multipliers, respectively, ranked 16 or 17. Finally, the large service-oriented sectors in Table 1, wholesale, eating and drinking establishments, miscellaneous services, and retail are important to any regional economy, not because they have high multipliers, but because they are important input suppliers to the high multiplier sectors, i.e., they account for a significant part of the multipliers of high multiplier sectors.

To further explore the potential future impacts of these high impact sectors on the regional economy, we need to determine whether these sectors are likely to grow or decline in the future. For the purposes of this study, we use regional employment trends.[6/] In Table 3, regional employment trends for 1960 to 1980 are shown for many of the sectors listed in Tables 1 and 2. The data in table 3 are from Ohio Bureau of Employment Services [12] publications and the I/O model data are developed from a detailed County

6. See footnote 4.

TABLE 3
Regional Employment and Employment Changes for Selected Sectors, 1960, 1970 and 1980

	1960	1970	1980	1970-80 Percent Change
Construction	60,460	64,312	66,715	+ 3.7
Food & Kindred Products	31,261	26,986	21,054	- 21.7
Textiles*	NA	11,330	8,080	- 28.7
Chemicals & Allied Products	22,857	26,141	26,307	+ 0.6
Rubber & Leather Products	59,836	59,384	49,358	- 16.9
Primary Metals +	103,339	102,819	76,705	- 25.4
Fabricated Metals†	58,625	66,078	79,037	+ 19.6
Electric & Electronic Equipment	NA	47,803	47,451	- 0.7
Transportation Equipment§	78,947	77,620	63,065	- 18.7
Transportation	43,464	48,483	45,691	- 5.8
Water Transportation*	NA	6,060	2,564	- 57.7
Electricity, Gas & Sanitary	14,024	14,935	15,850	+ 6.2
Wholesale	73,562	85,375	108,383	+ 26.9
Retail	191,727	252,608	309,551	+ 22.5
Eating & Drinking Est.*	33,694	44,725	68,695	+ 53.6
Finance & Insurance	36,138	49,767	64,771	+ 30.1
Services	84,230	126,369	328,041	+159.6
Auto Repair*	5,197	6.977	8,594	+ 23.2
Health*	4,139	11,416	96,059	+741.4

Source: Computed from OBES [12], 1960, 1970, 1980.

* Data reported for a limited number of counties.

\+ Includes primary iron and steel manufacturing and primary nonferrous metals.

† Includes heating, plumbing and fabricated metals.

§ Includes motor vehicle equipment.

Business Patterns [14] data tape for 1978. Thus, several sectors of interest are omitted from Table 3 and several others are partially reported because of data availability limitations.

Matching as best we can the sectors in Table 3 with those of the I/O model shows that the sectors in Table 3 account for over 80 percent of regional output, income, and employment in 1978. Those sectors which show increased employment in 1980 as compared to 1970 account for 55 percent of output, 50 percent of income and 63 percent of employment, while those which show decreased employment account for 30 percent of output, 31 percent of income and 21 percent of employment. The average output per man-year of employment is $76,500 for the employment increasing sectors as compared to $122,600 for the employment decreasing sectors. Similarly,

income per man-year is $8,900 for employment increasing as compared to $16,300 for employment decreasing sectors. Employment in this region, and probably in other similar regions, is shifting from high output and income per man-year sectors toward lower output and income per man-year sectors.[7/]

The data in Table 3 clearly shows the large regional employment declines in the manufacturing sectors, which are well known. These declining sectors include transportation equipment, in which the high impact sector "motor vehicle equipment" is contained. Primary iron and steel (metals), and rubber and leather products are other higher impact sectors which show large employment growth declines in the region. However, significant employment has occurred in fabricated metals, which contains the high impact sector "heating, plumbing and fabricated metals." Finance and insurance, the third high impact sector, has also shown significant employment growth. Other higher impact sectors showing employment growth are construction, health services, and electricity, gas, and sanitary. Employment in chemicals and allied products, and electric and electronic equipment has been stable over 1970 to 1980. The growth rates of retail and services are biased upward because changes in unemployment compensation coverage have required many firms to report to the Ohio Bureau of Employment Services in 1980 that did not have to report in 1970 or 1960.

Implications for Regional Growth

The results of this study clearly demonstrate what is generally known. Northern Ohio, in particular the northeast, has experienced major negative economic impacts from declines in its core manufacturing sectors and the accompanying indirect impacts on related sectors. These core sectors have relatively large multipliers and are large in size.

Less well known is how the region can facilitate the current transition in order to again become a dynamic growth region. How can a region such as this, either through state policy or local economic development efforts, match its policy tools to various economic sectors? While a detailed study of matching policies and problems is beyond the scope of this paper, the results of this analysis suggest some general directions. For those sectors which are growing, facilitating policies are probably the most effective. Policies which facilitate or reduce costs of new or expanded plants, labor force, or transportation services for the important growing sectors of heating, plumbing, and fabricated metals, finance and insurance, construction, health services, or electricity, gas, and sanitary are likely to be effective. Job retraining programs to assist employees in moving from the declining employment sectors of motor vehicle equipment, primary iron and steel, and rubber and leather products to one of the growing sectors merit attention. A difficult problem in a region such as this, however, is that available jobs may involve reduced wages compared to what was earned in the declining industry. Finally, for

7. What this shift implies for regional (and national?) economic growth is an important issue, but beyond the scope of this study.

chemicals and allied products, and electric and electronic equipment, sectors which are showing stable employment, visitation committees and labor management committees may be effective in helping the region retain those firms currently operating in the region.

APPENDIX TABLE A
Sector Output, Employment and Income for the Region, 1978

Endogenous Sectors	Output* ($ million)	Employment+ (man years)	Income† ($ million)
Livestock	261.2§	4,729	155.6
Crops	3,507.6§	45,347	366.6
Forestry products	351.8	3,104	26.6
Commercial fishing	2.5¶	52	.4
Mineral extraction	87.7	1,167	23.3
Other mining	288.9	970	29.3
Construction	7,473.3	66,767	1,034.3
Food and kindred products	2,778.0	17,179	240.5
Textiles	1,372.9	14,925	220.0
Wood and lumber	317.8	3,151	38.4
Furniture and fixtures	429.8	6,277	84.1
Paper and allied products	950.1	9,598	158.9
Printing and publishing	1,148.5	22,257	327.6
Chemicals and allied products	7,042.3	21,875	421.7
Rubber and leather products	4,744.5	48,711	600.0
Stone, clay, and glass products	1,723.6	20,460	317.5
Primary iron and steel mfg.	11,081.2	67,128	1,010.8
Primary nonferrous metals	3,008.4	21,099	328.6
Heating, plumbing fabricated metals	5,297.9	54,215	730.4
Other fabricated metals	2,301.0	20,561	312.0
High technology machinery	1,387.2	16,638	255.7
Miscellaneous machinery	6,876.3	64,933	1,017.9
Electric and electronic equipment	4,912.6	57,990	1,103.6
Motor vehicle equipment	13,823.9	87,957	1,722.2
Boat-ship building and repair	125.9	2,518	45.3
Other manufacturing	371.8	6,259	19.7
Water transportation	178.0	2,324	51.5
Non-water transportation	2,618.8	44,261	630.8
Communication	859.6	21,704	349.6
Electricity, gas and sanitary	5,112.0	17,648	294.6
Wholesale	7,751.2	95,838	1,366.9
Retail	3,401.6	194.979	1,441.1
Finance and insurance	6,301.1	60,693	712.8
Real estate	3,429.5	17,852	165.0
Hotel and lodging	353.5	13,599	69.0
Eating and drinking establishments	3,938.0	81,385	373.2
Auto repair services	1,706.5	10,604	104.9
Recreation and amusement	504.5	15,028	87.2
Charter fishing	2.0	42	.7
Marina and boat sales	91.9	3,790	25.5
Education services	603.8	16,053	188.8
Health services	20,546.8	106,470	1,305.0
Miscellaneous services	10,610.1	326,003	1,279.2
Total	149,675.6	1,714,140	19,036.8

* Computed as regional employment times national sectoral average productivity.
\+ [14]
† Computed as regional employment times sectoral average annual per capita earnings.
§ [11]
¶ [4]

APPENDIX TABLE B
Output, Employment and Income Multipliers (Rank) for Regional Endogenous Sectors, 1978*

Endogenous Sectors	Multipliers		
	Output	Employment	Income
Livestock	2.13 (3)	1.74(22)	2.69 (4)
Crops	1.64(32)	1.51(33)	1.61(32)
Forestry Products	1.33(43)	1.51(32)	1.24(42)
Commercial Fishing	1.67(31)	1.50(34)	1.57(34)
Mineral Extraction	1.79(21)	1.61(27)	1.74(27)
Other Mining	1.61(34)	2.84 (4)	1.52(36)
Construction	1.72(28)	2.21(10)	1.82(21)
Food and Kindred Products	2.06 (5)	2.00 (3)	2.58 (6)
Textiles	2.03 (6)	2.00(14)	2.72 (3)
Wood and Lumber	1.50(36)	1.57(28)	1.64(31)
Furniture and Fixtures	1.94(12)	1.69(26)	2.22(11)
Paper and Allied Products	1.77(23)	1.84(20)	1.95(15)
Printing and Publishing	1.62(35)	1.46(36)	1.55(35)
Chemicals and Allied Products	1.85(17)	3.47 (1)	1.97(14)
Rubber and Leather Products	1.87(16)	1.83(21	1.92(16)
Stone, Clay, and Glass Products	1.76(25)	1.73(23)	1.78(24)
Primary Iron and Steel Manufacturing	1.74(26)	2.15(11)	1.80(22)
Primary Nonferrous Metals	1.96(10)	2.31 (9)	2.25 (9)
Heating, Plumbing Fabricated Metals	2.01 (8)	1.92(15)	2.20(12)
Other Fabricated Metals	1.83(18)	1.91(16)	1.82(20)
High Technology Machinery	1.81(19)	1.73(24)	1.76(26)
Miscellaneous Machinery	1.81(20)	1.88(17)	1.77(25)
Electric and Electronic Equipment	1.89(15)	1.85(19)	1.90(17)
Motor Vehicle Equipment	2.37 (1)	3.12 (2)	3.22 (1)
Boat-Ship Building and Repair	2.03 (7)	1.55(29)	2.28 (8)
Other Manufacturing	1.99 (9)	1.71(25)	2.37 (7)
Water Transportation	2.12 (4)	2.09(13)	2.58 (5)
Non-water Transportation	1.67(30)	1.54(30)	1.59(33)
Communication	1.40(39)	1.27(40)	1.28(40)
Electricity, Gas, and Sanitary	1.63(33)	2.50 (8)	1.64(30)
Wholesale	1.37(41)	1.47(35)	1.25(41)
Retail	1.35(42)	1.09(43)	1.24(43)
Finance and Insurance	1.96(11)	2.58 (7)	2.09(13)
Real Estate	1.40(40)	1.88(18)	1.30(39)
Hotel and Lodging	1.67(29)	1.22(42)	1.64(29)
Eating and Drinking Establishments	1.77(24)	1.42(38)	1.87(19)
Auto Repair Service	1.93(13)	2.62 (6)	1.87(18)
Recreation and Amusement	1.78(22)	1.44(37)	1.80(23)
Charter Fishing	2.24 (2)	2.83 (5)	2.24(10)
Marina and Boat Sales	1.92(14)	1.53(31)	2.87 (2)
Education Services	1.44(37)	1.22(41)	1.35(37)
Health Services	1.42(38)	2.11(12)	1.32(38)
Miscellaneous Services	1.74(27)	1.31(39)	1.72(28)

* Rank is in parentheses.

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