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An Input-Output Analysis of Oklahoma's Economy

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An Input-Output Analysis of Oklahoma's Economy

Charles H. Little and Gerald Doeksen*

Oklahoma has a wide variety of economic activity. These activities range from individually operated farms to the large industrial and service firms located near the metropolitan centers of Tulsa and Oklahoma City. Efforts to understand the complex economic system are being made by leaders in agriculture, business and government, who desire to know how various development programs will affect the economy of the state. State agricultural leaders want to know how a proposed farm program will affect the income of farmers, business leaders are concerned how a new industry will affect the business activity in their community, and governmental leaders desire to know what effect highway construction will have on the economy. To evaluate public programs for economic development, measures are needed of all the effects of an induced change in the economy. An analysis of the economic structure or economic base of a region can provide the means for measuring the effects. An input-output analysis is one type of economic base study.

Need for the Study

In order to measure the total effect that a change will have on the entire economy it is necessary to examine both direct and indirect effects. The direct effect of a proposed change is relatively simple to ascertain, but indirect effects are not as easily measured. For example, if a new plant is located in a community the initial effect on employment will be the number of men the new plant will employ. The indirect effects created by the location of the new plant are the increased employment opportunities resulting in other businesses in the region. These indirect effects arise as the new plant and its employees demand additional goods and services. Industries supplying this demand in turn will increase their demand for goods and services from other industries. These industries will have to hire more men. The reverberations will continue until the economy adjusts completely to the initial change. All repercussions of the new plant on employment and income are included in the total effect.

One analytical device used to measure the total effect of an induced

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change in the economy is the input-output model.[1] A model was constructed for the Oklahoma economy to measure the total effect of a change in the sectors included in the model. Each sector consists of a group of similar-type industries. Various predictive indicators can be computed from the input-output analysis. These are the output, income, and employment multipliers. The output multipliers, for example, indicate how much output is expected to change throughout the economy as a result of a one unit change in a sector. Once these indicators are known, they can be used to evaluate the interrelationship among the various sectors of the economy of Oklahoma.

Objectives of the Study

The general objective of this study was to measure the interrelationship of the sectors of the economy of Oklahoma. Emphasis was focused on the main economic activities found in the state. Another objective was to derive a method to measure leakage from a state economy using the input-output analysis. More specifically, the objectives of the study were:

1. To formulate an input-output model to study the interrelationships of the economy;
2. To measure the direct and indirect effect of changes in economic activities;
3. To illustrate how changes in final demand will effect output, employment, and income;
4. To compute output, income, and employment multipliers;
5. To measure the amount of leakage associated with each multiplier;
6. To illustrate how the input-output model can be used as a predictive device.

The empirical results are intended to illustrate the structure of the state's economy so that leaders in agriculture, business, and government can evaluate various proposed economic development programs.

Oklahoma Model

The data used in the study were for the year 1959, primarily because secondary data for this year were the most complete of all available data. Secondary data were used because of the prohibitive time and cost necessary for the collection of primary data. When state data were not available in the necessary form, data from the national input-output

[1]For a description of the input-output model see, Gerald A. Doeksen and Charles H. Little, "Basic Input-Output Theory," Okla. Agri. Exp. Sta. Processed Series P-577 (Stillwater, 1967).

model were adjusted where necessary in light of relevant information on the economy of Oklahoma.

The industries in the economy had to be aggregated into a workable number of sectors. Also the amount of available data was often restricted to groups of industries or activities as classified by the Bureau of Labor Statistics. It was necessary to decide which groups of industries reported according to this classification should be included in the model.

Agricultural activities were divided into two sectors: the crop and the livestock and livestock products sectors. This division allowed the two main agricultural enterprises in the state, wheat and cattle, to be studied separately.

Because of the large amount of agricultural products being processed in Oklahoma, a separate sector was included for the agricultural processing firms. The remaining industrial firms were aggregated into the manufacturing sector. The service-type activities of the economy were aggregated into five sectors: transportation, communication and public utilities; real estate, finance and insurance; wholesale and retail trade; and service. Also since the mining of crude oil plays an important role in the economy of Oklahoma, a separate sector for mining activity was included. These are the processing or endogenous sectors of the model.

Seven exogenous or final demand sectors were considered. Construction activities were divided into new construction and maintenance construction. Also the government activities were split into two sectors: federal, and state and local. The other exogenous sectors were households, imports and exports. A complete listing of the endogenous and exogenous sectors is given below:

Endogenous Sectors	**Exogenous Sectors**
Livestock and Livestock Products	Maintenance Construction
Crops	New Construction
Agricultural Processing	Federal Government
Manufacturing	State and Local Governments
Transportation, Communications and Public Utilities	Households
	Exports
Real Estate, Finance and Insurance	Imports
Services	
Wholesale and Retail	
Mining	

The Inter-Industry Flow Table

The inter-industry flow of goods and service (Table I) provides the base for analysis of the input-output model. This table presents the dispersion of each sector's output among the purchasing and final demand sectors. Each row entry represents the dollar amount of goods or services

sold by the producing sector to the purchasing sector represented by each column. Reading across the first row of Table I, for example, the livestock and livestock products sector sold 83.5 million dollars of goods to farmers within that sector, 117.9 million dollars of goods to the agricultural processing firms, 0.5 million dollars of goods to the manufacturing firms, 3.4 million dollars of goods to the real estate, finance and insurance sector, 0.4 million dollars to the service sector, 0.1 million dollars to the state and local governments, 17.0 million dollars to households and 168.4 million dollars of goods were exported from the state. The agricultural processing sector purchased large quantities of raw materials from the livestock producer, which were mainly slaughter animals, milk products, and eggs. Purchases of hides accounted for the major portion of the sales of livestock products to the manufacturing sector. The real estate, finance and insurance sector purchased a small amount of miscellaneous livestock products. The purchases by the service sector were small and were used mainly for recreational purposes. A small amount was purchased

Table I. Inter-Industry Flows of G

	Lvsk. & Lvsk. Products	Crops	Agric. Proc.	Manf.	Trans., Comm. & Pub. Ut.	Real Est. Fin. & Ins.	Service
	Thousand Dollars						
Livestock and Livestock Products	83,539	[a]	117,923	520	—	3,372	433
Crops	101,108	18,011	64,790	10,319	340	5,269	866
Agricultural Processing	31,427	—	68,076	2,213	913	193	19,030
Manufacturing	6,287	38,982	34,377	377,952	42,875	31,470	150,717
Transportation, Communication and Public Utilities	14,261	11,476	19,840	110,309	69,265	8,252	66,879
Real Estate, Finance and Insurance	3,705	9,856	3,473	29,340	9,694	31,260	11,223
Services	2,620	8,691	17,995	64,037	26,297	14,102	74,412
Wholesale and Retail	14,747	20,897	17,409	180,438	17,613	12,643	28,688
Mining	101	1,382	374	474,545	18,066	632	433
Construction							
Maintenance	1,650	2,659	1,205	2,805	25,614	7,824	957
New	3,739	6,024	2,011	27,015	34,955	21,284	2,605
Government							
Federal	837	2,161	10,308	37,510	91,757	31,392	8
State and Local	12,372	16,286	7,426	40,698	35,925	4,965	3,.
Households							
Wages and Salaries	11,047	26,953	66,000	330,000	242,000	102,000	230
Proprietor Income	94,031	147,968	10,000	35,000	29,000	48,000	157,000
Rent Income	3,458	20,642	1,602	17,884	14,439	13,946	36,903
Imports	6,336	18,090	24,283	177,955	21,247	14,668	74,407
Total	391,265	350,078	467,092	1,918,540	680,000	351,272	865,890

[a] Dash indicates zero or negligible quantity.

by state and local governments. The value of goods and services purchased by households equaled 17 million dollars. Included in this figure was the amount used by the producer himself and the amount purchased for final consumption directly from the farmer by the households. The entry in the export column indicated that Oklahoma produces more livestock and livestock products than were consumed in the state. The major share of these exports was cattle and calves, which make up the bulk of the livestock sector. Entries in the table for the remaining sectors can be interpreted similarly.

The entries in each column of Table I represent the input structure of each purchasing or consuming sector. As an illustration, consider column three. The agricultural processing sector purchased 182.7 million dollars of goods from the basic agricultural sectors, which includes the crop and the livestock and livestock products sectors. Of this amount, 117.9 million dollars was for livestock products, while 64.8 million dollars was purchased from the crop sector. The main items purchased from the

a. Services, Oklahoma Economy, 1959

Wholesale and Retail	Mining	Construction		Government		Household	Export	Total
		Maintn.	New	Federal	State & Local			
Thousand Dollars								
—	—	—	—	—	109	16,979	168,390	391,265
	—							
1,818	—	—	2,885	32,360	—	21,763	90,549	350,078
5,724	—	—	192	5,663	2,952	330,709	—	467,092
89,908	87,138	70,289	183,465	177,051	43,884	584,145	—	1,918,540
43,410	36,921	7,840	25,257	55,974	23,335	183,084	3,897	680,000
20,097	15,281	1,132	5,317	212	16,335	154,959	39,388	351,272
92,420	85,346	3,205	38,149	36,499	22,663	379,454	—	865,890
34,956	42,967	31,915	60,582	84,749	21,006	567,690	—	1,136,300
114	51,234	3,027	7,628	5,293	1,909	2,315	293,577	860,630
2,630	6,518	—	64	3,322	33,634	127,999	—	216,881
'55	29,109	—	—	8,139	82,395	365,542	—	589,973
72	14,706	2,600	7,072	6,135	5,213	560,349	—	809,867
402	42,296	2,922	7,948	91,950	—	251,536	—	542,008
000	266,000	42,739	116,261	358,000	258,000	7,000	—	2,521,000
203,000	21,000	17,203	46,797	—	—	15,955	—	829,954
64,202	120,000	809	2,567	3,000	12,398	189,150	—	501,000
44,692	42,114	33,202	85,788	84,655	21,389	318,590	—	967,416
1,136,300	860,630	216,883	589,972	953,002	545,222	4,077,219	595,801	

livestock sector were slaughter animals, whereas the crop sector sold mostly wheat and other grains to the agricultural processing sector. The agricultural processing industries purchased 68.1 million dollars worth of goods and services from other industries within the sector. Most of the 34.4 million dollars spent for manufactured products was for packaging materials needed in the operation of the processing industries. The processing sector spent 19.8 million dollars for transportation, communication, and public utilities, whereas their expenses for services from the real estate, finance and insurance sector totaled 3.5 million dollars. The purchases from the other endogenous sectors were: service sector, 18.0 million; retail and wholesale, 17.4 million; and mining, 0.4 million dollars. The agricultural processing sector spent 3.2 million dollars on new and maintenance construction. It also paid 17.7 million dollars in taxes. Workers received 66.0 million dollars in wages and salaries, while the amount of proprietor income and rent paid by the agricultural processing sector totaled 10.0 million dollars and 1.6 million dollars respectively. Materials imported from outside the state totaled 24.3 million dollars. These imports consist mostly of manufactured products. The remaining columns can be interpreted similarly.

Of special interest in Table I is the export column and the import row. It is obvious that Oklahoma is a large exporter of agricultural and mining products. These figures were computed by determining the total demand of each sector and the amount of the product used for final consumption within the state. The amount produced above these demands was the amount exported. Computed in this way, this figure is the amount of net exports. The amount imported was also a net figure. The excess of demands above that which was produced within the state was imported. The amount imported by each sector was determined by assuming its share of the total imports was equal to the proportion it used of the total demand in the state. Therefore, each sector had an import entry, which consisted mainly of manufactured products. In fact, 92 percent of the net imports in Oklahoma were manufactured products.

Technical Coefficients

The technical coefficients in Table II show the direct purchases of each sector from every other sector per dollar of output. The technical coefficients are relevant only for the processing sectors; therefore, technical coefficients are not computed for the final demand sectors. By considering a particular column, say column four, the technical coefficients can be interpreted as follows. If the manufacturing sector increases its output by one dollar, its purchases from the agricultural sectors will change very little. However, purchases among manufacturing industries

Table II. Technical Coefficients, Oklahoma Economy, 1959

	Lvsk. & Lvsk. Products	Crops	Agric. Proc.	Manf.	Trans., Comm. & Pub. Ut.	Real Est., Fin. & Ins.	Service	Whole-sale & Retail	Mining
Livestock and Livestock Products	.21351	.00000	.25246	.00027	.00000	.00960	.00050	.00000	.00000
Crops	.25841	.05145	.13871	.00538	.00050	.01500	.00100	.00160	.00000
Agricutural Processing	.08032	.00000	.14574	.00115	.00134	.00055	.02198	.00504	.00000
Manufacturing	.01607	.11135	.07360	.19700	.06305	.08900	.17416	.07912	.10125
Transportation, Communication, and Public Utilities	.03645	.03278	.04247	.05750	.10186	.02349	.07724	.03820	.04290
Real Estate, Finance and Insurance	.00947	.02815	.00744	.01529	.01426	.08959	.01296	.01769	.01776
Services	.00670	.02483	.03852	.03338	.03867	.04015	.08594	.08134	.09916
Wholesale and Retail	.03769	.05969	.03727	.09405	.02590	.03599	.03313	.03076	.04992
Mining	.00026	.00395	.00080	.24735	.02657	.00180	.00050	.00010	.05953
Construction									
Maintenance	.00422	.00760	.00258	.00146	.03767	.02227	.00111	.00232	.00757
New	.00956	.01721	.00431	.01408	.05140	.06059	.00301	.00630	.03382
Government									
Federal	.00214	.00617	.00207	.01955	.13493	.08937	.00930	.02796	.01709
State and Local	.03162	.04652	.01590	.02121	.05283	.01413	.00379	.02147	.04914
Households									
Wages and Salaries	.02823	.07699	.14130	.17201	.35588	.29037	.26562	.40922	.30910
Proprietor Income	.24033	.42267	.02141	.01824	.04265	.13665	.18130	.18305	.02440
Rent Income	.00883	.05996	.00343	.00932	.02124	.03970	.04262	.05650	.13943
Total	.27739	.55862	.16614	.19957	.41977	.46672	.48954	.64877	.47293
Imports	.01619	.05168	.05199	.09276	.03125	.04175	.08594	.03933	.04893
Total	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

within the sector will increase by 20 cents. To meet this new output, the manufacturing sector will buy 6 cents worth of goods and services from the transportation, communication and public utility sector; 2 cents worth of services from the real estate, finance and insurance sector; 3 cents worth of services from the service sector; 9 cents worth of services from the retail and wholesale sector; and 25 cents worth of goods and services from the mining sector. As expected the manufacturing sector has a large direct effect with the mining sector, because a large part of the manufacturing in the state consists of processing raw products from the mining sector. The one dollar increase in output of the manufacturing sector will cause the exogenous sectors to change as follows: 2 cents will be spent on construction (new and maintenance), 4 cents will be paid to government (federal, state, and local), 17 cents will be paid for wages and salaries, 3 cents will be paid for rent and proprietor income, and 9 cents will be paid for imports.

The technical coefficients are assumed constant over time, thereby assuming no change in technology. If forecasts are desired, new flow tables will have to be constructed regularly or present tables will have to be adjusted to account for technological changes. An up-to-date technical coefficient table can be used to analyze the direct effects of changes in each sector of the economy.

Interdependence Coefficients

The interdependence coefficients in Table III indicate the total change in input requirements as a result of a one dollar change in final demand in a sector. The total change includes the direct effect as well as all indirect effects resulting from the initial one dollar change. For illustration purposes, consider a one dollar change in demand for products of the livestock sector. Column I of Table II shows that this would directly change intra-industry transactions by 21 cents. However, as the livestock industry changes its own output, the amount of purchases from the other sectors will also change. As the amount of purchases from other sectors change, each sector will change its output to meet the new demand. These sectors in turn will change their purchases from every other sector, including the livestock sector. This secondary change on the livestock sector is referred to as the indirect effect. The interdependence coefficients in Table III indicate the combined direct and indirect effects. By substracting the technical coefficients (Table II) from the interdependence coefficients, the indirect effect is obtained.

An analysis of a change in a sector can be obtained by examining the appropriate columns in the last two tables. For example, a listing of the coefficients for the livestock sector is presented in Table IV. From

Table III. Interdependence Coefficients, Oklahoma Economy, 1959

	Lvsk. & Lvsk. Products	Crops	Agric. Proc.	Manf.	Trans., Comm. & Pub. Ut.	Real Est., Fin. & Ins.	Service	Whole-sale & Retail	Mining
Livestock and Livestock Products	1.31225	.00137	.38915	.00292	.00167	.01506	.01112	.00354	.00203
Crops	.37735	1.05689	.28510	.01033	.00284	.02336	.01096	.00553	.00313
Agricultural Processing	.12553	.00243	1.21069	.00604	.00406	.00455	.03109	.00965	.00471
Manufacturing	.12589	.18375	.20920	1.34527	.11909	.15737	.27903	.14221	.19020
Transportation, Communication and Public Utilities	.09202	.06268	.11317	.12106	1.13266	.05143	.12480	.06664	.08237
Real Estate, Finance, and Insurance	.03324	.04038	.03267	.03649	.02298	1.10587	.02640	.02652	.03005
Services	.04799	.05398	.09185	.10927	.06474	.06807	1.12755	.10792	.14061
Wholesale and Retail	.09859	.09090	.11005	.15825	.04855	.06456	.07623	1.05487	.08450
Mining	.03786	.05466	.06068	.35743	.06342	.04511	.07764	.03954	1.11581
Output Multipliers	2.25074	1.54703	2.50257	2.14707	1.46001	1.53547	1.76481	1.45641	1.65342

Table IV. Effects of One Dollar Increase in Output in Livestock Sector

	Total Effect	Direct Effect	Indirect Effect
Livestock and Livestock Products	1.31	1.21	.10
Crops	.38	.26	.12
Agricultural Products	.13	.08	.05
Manufacturing	.13	.02	.11
Transportation, Communication & Public Utilities	.09	.04	.05
Real Estate, Finance and Insurance	.03	.01	.02
Services	.05	.01	.04
Wholesale and Retail	.10	.04	.06
Mining	.04	.00	.04

the table, it is obvious that the basic agricultural sectors have the largest direct and indirect effects as a result of the initial increase. The change in demand for livestock products will cause farmers to change their requirements for breeding animals and feeder animals, thus causing the large direct and indirect change in that sector. A change in feed requirements as a result of the change in the livestock sector accounts for the direct and indirect effects of the crop sector. The manufacturing sector has the largest indirect effect of the non-agricultural sectors. The remaining non-agricultural sectors have small indirect effects as a result of the small interaction between these sectors and the livestock sector. A table indicating the direct, indirect, and total effects could be constructed for each sector.

The interdependence coefficient table is very useful for those working with the adjustment problem. From this table, the effects of a change in the economy can be determined. Forecasts can be made of the effect of the change on output, income and employment in Oklahoma.

Empirical Predictive Devices

Input-output multipliers are used to determine what effect a change in demand for goods and services from a particular sector will have on total output, employment and income. The output multiplier indicates how the production of each sector will change as output is changed in any one of the sectors. If employment is changed in a sector, the employment multiplier indicates how this change will affect employment in the rest of the economy. Similarly, the income multiplier measures the effect a change in income in a sector will have on the rest of the economy.

Output Multipliers

Output multipliers measure the amount of output generated by a one dollar change in final demand for products of a particular sector. They are computed directly from the interdependence coefficients (Table III) by adding down the column for each sector to obtain the output multiplier of that purchasing sector. For example, from Table III, by adding down the column for the livestock and livestock products sector, the output multiplier for this sector is 2.25. This indicates that a one dollar change in final demand for livestock and livestock products will cause a change in total output of $2.25. Of this total, $1.31 is generated by interaction among industries within the livestock sector and $.38 by interaction with industries in the crop sector. These two figures account for a major part of the multiplier.

The output multipliers computed from Table III for each sector are listed in column (1) of Table V. The agricultural processing sector has the largest multiplier. If demand for products in this sector changes by one dollar, there will be a change in output of $2.50. The size of the multiplier indicates the large interaction of this sector with the other sectors, especially the two basic agricultural sectors. From Table III, it is seen that a one dollar change in output for agricultural processing products requires a change of $.39 from the livestock and livestock products sector and $.29 from the crop sector. Also, a rather large amount is purchased from the manufacturing sector, which is mainly packaging

Table V. Output Multipliers and Leakage in the Oklahoma Model

	Output Multiplier (1)	Output Multiplier: No Import Assumption (2)	Output Multiplier Leakage (3)
Livestock and Livestock Products	2.25	2.44	.19
Crops	1.55	1.77	.22
Agricultural Processing	2.50	2.83	.33
Manufacturing	2.15	2.57	.42
Transportation, Communication & Public Utilities	1.46	1.61	.15
Real Estate, Finance and Insurance	1.54	1.74	.20
Services	1.76	2.12	.36
Retail and Wholesale	1.46	1.64	.18
Mining	1.65	1.89	.24
Economy Multipliers	1.81	2.07	.26

materials. The initial change in the agricultural processing sectors causes an $.11 change in the activities of the transportation, communication, and public utilities sector, principally because of the movement of the raw materials to the processing plant and then the movement of finished products from the plant to the retailer or wholesaler. The change in the wholesale and retail sector is $.11 per dollar change in output of the agricultural processing setcor. Results of the initial change are relatively small in the remaining three sectors.

The third largest output multiplier as seen from Table V is that of the manufacturing sector. A look at Table III indicates that the manufacturing sector has a large amount of interaction with industries within the manufacturing sector and with industries in the mining sector. The total effect is $1.35 from industries within the manufacturing sector, and $.36 from industries within the mining sector. Direct and indirect effects of a dollar change in demand for manufactured products on transportation, communication and public utility; service; and wholesale and retail sectors are $.12, $.10, and $.16 respectively. The remaining sectors are influenced very little by the increase in demand of manufactured products.

The output multipliers of the crop and mining sectors look somewhat small. However, the interdependence of these sectors with industries within the other sectors is small. There has been under-utilization of resources in agriculture in the past and this is reflected in the interdependence coefficients. With an increase in demand for agricultural products, many resources were used more intensively and the new output requirements were met with little additional increase in the demand for these inputs. This explains why the interdependence between the crop sector and the other sectors is small. Also, for the same reason an increase in demand for mining products will not affect the other sectors to a large extent. The figures in Table III indicate that only three sectors will change by a sizeable amount if the demand for mining output is increased by one dollar. These are the manufacturing, service, and mining setcors, which will increase their activities by $.19, $.14, and $.12 respectively.

The output multipliers of the other sectors are small. These sectors are similar in nature and could be called service-type sectors as their activity depends on the activities of the primary sectors (manufacturing, mining, agricultural, and agricultural processing) and of the final demand sectors. Also these sectors are rather labor intensive and purchase less from the primary sectors, thus a smaller output multiplier would be expected.

Assuming that final demand changes in all sectors simultaneously by one dollar, this change in demand would generate a change in output

of $16.32. Dividing this total by the amount of the change in demand would indicate that every dollar change in demand would generate on the average a change in output of $1.81. This $1.81 is an average output multiplier of the endogenous sectors, and is referred to as the economy multiplier in Table V.

An interesting result is obtained by assuming that the Oklahoma economy produces all of the products demanded by the producing and final demand sectors. In other words, no goods and services are imported from outside the state. To compute the multiplier under this assumption, the amount of imports in the import row are distributed among the endogenous sectors in each column. The export column remains in the flow table; however, the figure for each sector is reduced by the amount of imports added to the sector. Again the column and row total are equal for the endogenous sectors.

The sector multipliers computed under this assumption are listed in column (2) of Table V. Again assume that final demand changes by one dollar in each sector. The total change in output generated throughout the economy would be $18.61. Dividing this by the total demand change will yield an economy output multiplier of $2.07.

The difference between the multipliers in column (1) and (2) can be referred to as the leakage associated with the output multiplier effect. Leakage is defined as the net amount of the change in total output which is obtained outside the state as a result of the one dollar change in final demand in Oklahoma. The leakage effect for each sector is listed in column (3) of Table V. The manufacturing sector has the largest amount of leakage, since most of the net imports for Oklahoma are manufactured products. The large amount of imports of manufactured products determines to a great extent the magnitude of the remaining leakage figures as all sectors demand large quantities of products from the manufacturing sector. This is verified by the interdependence coefficients listed in the row of the manufacturing sector on Table III.

In summary, the two economy multipliers indicate that a one dollar increase in final demand in Oklahoma will generate $2.07 worth of new output. Of this increased output, $1.81 worth of goods and services will be produced within Oklahoma. This leaves a net leakage for the economy of Oklahoma of $.26, that is, $.26 worth of goods and services are produced outside the state due to an increase in final demand of one dollar in the state.

Income Multipliers

The income multiplier measures the total change in income throughout the economy resulting from a one dollar change in income in a

sector. The concept of the input-output income multiplier was developed by Hirsch.[2] Computation procedure of the income multiplier is explained in Appendix A. The income multipliers are listed in column (1) of Table VI. The agricultural processing, manufacturing and livestock sectors have by far the largest income multipliers.

The income multipliers listed in column (2) are computed under the assumption that there are no imports in the Oklahoma economy. The difference between these multipliers and those in column (1) is the net leakage associated with the income multiplier. The leakage effect is listed in column (3). Income leakage is defined as the net amount of the new income which is generated outside the state as a result of a one dollar increase in income in Oklahoma. In examining the column for leakage, the manufacturing and agricultural processing sectors have the largest amount of income leakage.

The agricultural processing sector has the largest income multiplier. This sector depends heavily on raw materials from the basic agricultural sectors as well as packaging materials and equipment from the manufacturing sector. The reliance on the manufacturing sector accounts for the high leakage figure since most of the imports in Oklahoma are manufactured products. The manufacturing sector has the second largest income multiplier and the largest amount of leakage. This is because

[2]Warner Z. Hirsch, "Interindustry Relations of a Metropolitan Area," **The Review of Economics and Statistics**, XLI (November, 1959), pp. 360-369.

Table VI. Income Multipliers and Income Leakage in the Oklahoma Model

	Income Multiplier (1)	Income Multiplier: No Import Assumption (2)	Income Multiplier Leakage (3)
Livestock and Livestock Products	2.81	3.02	.21
Crops	1.40	1.52	.12
Agricultural Processing	4.32	4.92	.60
Manufacturing	3.35	4.01	.66
Transportation, Communication & Public Utilities	1.44	1.56	.12
Real Estate, Finance and Insurance	1.46	1.61	.15
Services	1.58	1.80	.22
Wholesale and Retail	1.28	1.37	.09
Mining	1.57	1.72	.15
Economy Multipliers	2.13	2.39	.26

most of the imports into the state are manufactured products used by the manufactured sector itself. The sector with the third largest income multiplier is the livestock and livestock products sector. Leakage in this sector is small, because this sector requires only a few imported products. The multiplier and leakage of the remaining sectors are somewhat similar.

Again assuming that income is increased by one dollar in each sector simultaneously, the $9 increase in income will generate $19.21 in income throughout the economy. Dividing this by the change in income yields an income multiplier of $2.13 for the economy of Oklahoma. If the same procedure is used to calculate an income multiplier for the economy under the assumption that Oklahoma produces all of the products used in the state, a dollar increase in income for each sector will yield $21.53 worth of income to the economy. The income multiplier for the economy computed as an average of the endogenous sectors is $2.39. The two multipliers indicate that for each dollar increase in income to the economy, $2.39 of new income is generated. Of this $2.39 increase in income, $.26 of it is generated outside the state of Oklahoma. The economy leakage figure is an average of the leakage effects for the endogenous sectors.

Employment Multipliers

The employment multiplier as computed from the input-output model is defined as the change in employment due to a one unit change in the labor force of a particular sector. The concept of the input-output employment multiplier was developed by Peterson and Moore.[3]. The computation procedure used to calculate the input-output employment multiplier is presented in Appendix B. The basic assumption in computing the employment multipliers of Oklahoma is that there is a linear relationship between employment and output in a sector. The relationship does not strictly hold for several sectors as output has been increasing while the number employed has been decreasing. For example, in the more capital intensive sectors, such as the agricultural and manufacturing sectors, new technology has replaced labor. So for these industries the estimated multipliers may be too high. Another condition, particularly relevant in the basic agricultural sectors, is the presence of underemployed resources and unused capacity. Mainly because of this condition, employment multipliers for the agricultural sectors were not computed. The linear assumption holds more nearly for the labor-intensive service sectors; therefore, the multipliers are more nearly correct.

[3]Frederick T. Moore and James W. Peterson, "Regional Analysis: An Industry Model of Utah." **The Review of Economics and Statistics, XXXVII** (November, 1955), pp. 368-381.

Table VII. Employment Multipliers and Leakage in the Oklahoma Model

	Employment (1)	Employment Multiplier: No Import (2)	Employment Multiplier (3)
Livestock and Livestock Products	—*	—	—
Crops	—*	—	—
Agricultural Processing	2.82	3.35	.53
Manufacturing	2.93	3.52	.58
Transportation, Communication & Public Utilities	1.45	1.62	.17
Finance, Real Estate, and Insurance	1.55	1.71	.16
Services	1.33	1.44	.11
Wholesale and Retail	1.32	1.40	.08
Mining	2.56	2.94	.37
Economy Multipliers	2.00	2.28	.28

*Multipliers were not computed for sector.

Column (1) of Table VII shows the employment multipliers. Each multiplier indicates the change in employment generated throughout the Oklahoma economy by the one unit employment change in the sector specified. The manufacturing sector has the largest multiplier, because of the large amount of interaction of this sector with the other sectors. Also the agricultural processing sector and the mining sector have rather large employment multipliers due also to a large amount of interdependence with other sectors which have a high employment-output ratio.

The employment multipliers listed in column (2) are computed under the assumptions that there are no imports in the Oklahoma economy. These multipliers indicate the total amount of employment change per unit change in employment in Oklahoma. The difference between these multipliers and those listed in column (1) is the amount of leakage associated with each employment multiplier. Employment leakage is defined as the net amount of the employment change taking place outside the state due to a one unit change in employment in Oklahoma. Employment leakage figures [column 3] indicate that manufacturing has the largest leakage because of the large amount of manufacturing imports. The agricultural processing and mining sectors also have rather large leakage effects. The dependence of the activity of these sectors upon the activity of the manufacturing sector explains the magnitude of the leakage effect. The economy multipliers indicate that a one unit change in employment in Oklahoma will change total employment by 2.28 units. Of the 2.28 unit change, units employment in Oklahoma will change

by 2.00 whereas employment in areas outside of Oklahoma will change by 0.28 units.

Output Requirement for 1964 and 1975 Demand

The input-output model can be used to predict the change of output of each sector necessary to meet a change in final demand. The Oklahoma model was used to estimate output for 1964 and 1975. The actual output for each sector is available for 1964, so the predictions can be tested against the actual data. Also future employment needs for 1964 and 1975 necessary to meet this new output were estimated.

Final demand for the sectors in the Oklahoma model were estimated for 1964 and 1975. Final demand consists of local and export demand. Local demand is determined by economic activity in Oklahoma, whereas export demand is determined by economic activity elsewhere in the United States.

To estimate the final demand for the basic agricultural sectors in the Oklahoma model for 1964 and 1975, the work done by Rogers and Barton[4] was used. Rogers and Barton used population estimates, income trends, and expected consumer taste to arrive at changes in future demand. Most of their emphasis in predicting final demand was placed on changes in population. Their estimated change in demand from 1959 to 1975 for the United States was used to determine export demand. To arrive at the figures, it was assumed that the demand for agricultural exports from Oklahoma would be identical to the predicted change in United States demand for agricultural products. The export demand for the livestock sector computed from this assumption was expected to increase by 45 percent and the crop sector by 25 percent from 1959 to 1975. Local demand was determined by adjusting the estimated demand for the United States, using population data. United States' population was expected to increase by 23 percent between 1959 and 1975 while Oklahoma's population was expected to increase 17 percent between 1959 and 1975. The national expected change in demand for 1975 was adjusted downward according to the population trend to arrive at the local demand. Local demand was expected to increase by 42.8 percent in the livestock sector and 23.8 percent in the crop sector from 1959 to 1975.

To obtain estimates for 1964, the annual percentage change was calculated for both export and local demand. These annual percents were then used to derive the amount of export and local demand for the crop and livestock sectors. Changes in final demand for the agricultural processing sector were estimated by taking the weighted average

[4]Robert O. Rogers and Glen T. Barton, **Our Farm Production Potention 1967,** United States Department of Agriculture, Information Bulletin 233, 1960.

of the expected changes in the crop and livestock sector, weighting according to the sector's output. Local demand in the agricultural processing sector was expected to increase by 33 percent from 1959 to 1975 and 10 percent from 1959 to 1964.

The change in demand for the non-agricultural sectors were estimated from income data. Local demand was determined by assuming that demand for products from the non-agricultural sectors would increase at the same rate as personal income has been increasing in Oklahoma. Export demand was assumed to increase at the same rate as personal income has been increasing in the United States. Personal income has been increasing at an annual rate of 4.9 percent in Oklahoma, compared to 5.5 percent in the United States. Thus, local demand in Oklahoma was assumed to expand by 4.9 percent per year and export demand by 5.5 percent annually.

From the estimated percent changes, the amount that local and export demand is expected to change from 1959 to 1964 and from 1959 to 1975 can be computed. These estimates are obtained by multiplying the percentage change in demand times the 1959 demand and adding the results to the 1959 demand. Table VIII shows the amount of local and export demand for 1964 and 1975.

The output requirements for a sector necessary to meet the projected final demand was found by multiplying the sector of the total estimated final demand for each sector times the interdependence coefficients for each row. The output requirements for 1964 and 1975 are listed in columns (1) and (2) of Table IX.

A comparison of the prediction and the actual output for 1964 can be made by comparing columns (1) and (3) of Table IX. The estimates are similar to the actual values. The difference is small as the estimated total output is 2.8 percent greater than the actual output. Some of the variation can be caused by unexpected weather conditions, which cause the actual annual changes to deviate from the estimated changes.

By assuming that a linear relationship between employment and output holds for 1959, 1964, and 1975, an estimate of the change in employment can be computed. Of course, technology will change over time which would keep employment from expanding according to the assumed linear relation. Therefore, the employment estimate for each sector in columns (4) and (5) of Table IX should be adjusted downward to account for changing technology in each sector. The adjustment for technology will vary among sectors. It is expected that new technology will affect the primary and manufacturing sectors more than it will the service-type sectors. From columns (4) and (5) of Table IX, it can be seen that the service and wholesale and retail sectors have the largest demand for future employment. This is due to two reasons. First, de-

Table VIII. Predicted Demand Requirements for 1964 and 1975

	Local Demand		Export Demand		Total Demand	
	1964	1975	1964	1975	1964	1975
	(Thousands of Dollars)					
Livestock and Livestock Products	19,241	24,402	190,617	24,165	209,858	263,567
Crops	62,113	70,576	97,521	113,186	159,634	183,762
Agricultural Processing	373,463	454,272	—	—	373,463	454,272
Manufacturing	1,455,387	2,168,496	—	—	1,455,387	2,168,496
Transportation, Communication, and Public Utilities	375,272	605,164	5,093	8,694	380,365	613,858
Real Estate, Finance, and Insurance	226,005	264,454	51,480	87,875	277,485	452,329
Service	627,321	982,978	—	—	627,321	982,978
Wholesale and Retail	972,746	1,563,649	—	—	972,746	1,563,649
Mining	25,618	41,312	382,705	654,970	408,410	696,282

Table IX. Estimated Output and Employment for 1964 and 1975

1959	Output Needed to Meet Estimated Demand		1964	Estimated Man-Years Employment Needed for New Demand	
	1964 (1)	1975 (2)	Output (3)	1964 (4)	1975 (5)
	(000)	(000)	(000)		
Livestock and Livestock Products	441,241	561,510	441,214	—*	—
Crops	389,453	431,409	524,604	—*	—
Agricultural Process	521,299	650,776	524,604	18,976	23,690
Manufacturing	2,571,609	3,853,904	2,472,921	117,931	176,736
Transportation, Communication and Public Utilities	869,557	1,353,275	802,400	71,611	111,446
Real Estate, Finance and Insurance	448,891	713,125	470,704	37,088	58,919
Service	1,125,216	1,747,557	1,091,020	227,381	353,143
Wholesale and Retail	1,451,371	2,283,854	1,477,190	210,806	331,721
Mining	1,138,992	1,797,458	1,049,899	46,354	73,151

* Employment estimates were not computed for sector.

mand is increasing rather rapidly in these sectors, and second, these sectors are labor intensive.

In using the input-output model to predict future output requirements, it must be remembered that the assumption of fixed technical coefficients was used. However, technology is changing; therefore, some restriction must be placed on the length of the predictions. Generally, short-run estimates are reliable, as shown when the 1964 output requirements were predicted within 3.0 percent of the 1964 output. However, predictions made for a longer period of time should be carefully analyzed before conclusions are drawn.

Summary and Implications

The general objective of the study was to examine the interdependence of the structure of the economy of Oklahoma, using an input-output model. Secondary data were used to formulate the input-output model for Oklahoma. Economic activity within the state was classified into nine endogenous and seven exogenous sectors. The basic agricultural and mining sectors provide the raw materials for the agricultural processing and manufacturing sectors. The remaining producing sectors consist of service-type industries whose output depends directly on the demands of the agricultural, mining and manufacturing sectors as well as the final demand sectors.

The empirical results are reported in the flow table, technical coefficient table and the interdependence coefficient table. The flow table is the foundation of the model, and the other tables are computed directly from it. The flow table provides a double entry system of accounts, as sales and purchases of each sector are included in the table.

The technical coefficients reveal the direct dependence of each sector on the other sectors. The livestock and livestock products sector has a large direct effect with activities within the basic agricultural sectors, and the crop sector has a relatively large direct effect with the manufacturing sector. Of the industrial sectors, the technical coefficients between the agricultural processing and the basic agricultural sectors are large, while the manufacturing sector has a large direct effect with the mining sector. The technical coefficients also indicate that service-type sectors depend to a large extent on the manufacturing sector.

The interdependence coefficients measure the total effect of a change in demand for a sector, that is, both the direct and secondary changes. These coefficients indicate that economic activity in the livestock and livestock products sector is highly interdependent with the activity in the basic agricultural sectors, agricultural processing sector and manufacturing sector. Total activity in the crop sector is quite

heavily dependent on activity in the manufacturing sector. Of the industrial sectors, the interdependence coefficients between the agricultural processing sector and the basic agricultural and manufacturing sectors are large, while the manufacturing sector has a large total effect with industries within the manufacturing sector and with the mining setcor. The interdependence coefficients for the remaining sectors are large within the sector and with the manufacturing sector.

Implications

Implications from this input-output analysis are best seen by examining the various predictive devices, which were derived from the technical and interdependence coefficient tables. These predictive devices included three multipliers—output, income, and employment. Also future output and employment needs were forecasted. The predictions are greatly influenced by the present economic base of the state. As economic activity changes over time so will the forecasts. The technical coefficients of the model may change over time due to advances in technology. Since such changes were not accounted for in the analysis, conditions cannot be predicted too far into the future. As more information becomes available, it should be incorporated into the model, thereby providing better forecasts.

Output multipliers measure the change in output in the economy as a result of a one dollar change in output in a sector. The agricultural processing sector output multiplier at 2.50 is the largest. Thus, a change in output in this sector would generate more output throughout the economy of Oklahoma than an identical change in any other sector. The output multiplier of the livestock and livestock products sector of 2.25 is the second largest, while the output multiplier of the manufacturing sector at 2.15 ranks third. The output multiplier was also computed for the economy of Oklahoma and equals 1.81.

The agricultural processing sector also had the largest income multiplier. The multiplier for the agricultural processing sector indicates that a one dollar increase in income in this sector would increase income by 4.32 throughout the economy. The income multiplier for the manufacturing sector at 3.35 is the second largest, while the livestock and livestock products sector income multiplier at 2.81 ranks third. The income multiplier for the economy of Oklahoma is 2.13.

Of the employment multipliers, the manufacturing sector had the largest multiplier of 2.93. This indicates that for each man-year addition to employment in this sector, 2.93 additional man-years of labor will be hired throughout the economy. The employment multiplier for the agricultural processing sector at 2.82 is the second largest, while the employ-

ment multiplier for the mining sector at 2.56 ranks third. The economy employment multiplier for Oklahoma is 2.00.

Output, income, and employment leakage effects were computed for each sector. Leakage in each case is the net amount of change created outside the state as the result of a one unit change in a sector in Oklahoma. Of the leakage effects associated with the output multipliers, the manufacturing sector had the largest leakage effect at 0.42. The leakage effect of the output multiplier of the agricultural processing sector at 0.33 is the second largest. The greatest income multiplier leakage effects are also for the manufacturing sector and agricultural processing sector and are 0.66 and 0.60 respectively. These two sectors also have the largest employment multiplier leakage effects. The employment multiplier leakage effect for the manufacturing sector is 0.58, while the agricultural processing sector has a leakage effect of 0.53. The large leakage in these two sectors is due to the large amount of imports of manufactured products.

Multipliers and leakage effects reveal that an increase in final demand in the agricultural processing, livestock and livestock products and manufacturing sectors would generate more economic activity throughout the Oklahoma economy than similar changes in the other sectors. An expansion of economic activity in these sectors would encourage the development of industries which use the resources found in the state. Expanding the economic activity in these sectors would mean; (1) the livestock sector would demand more products from the crop sector produced in the state, (2) the agricultural processing sector would demand more raw materials from the crop and livestock sectors, and (3) the manufacturing sector would process more raw material products from the mining sector. If industries were encouraged to develop which depended very little on resources found in the state, then the amount of leakage would be large and less economic activity would be generated within the state.

Predictions for future output requirements were made for 1964 and 1975. The reliability of the model for predictive purposes was checked as the 1964 estimates were compared with the actual output. Over the five-year period from 1959 to 1964, the model predicted within three percent of the actual total output. The number of man-years employment to produce the estimated 1964 and 1975 output was also predicted. From these predictions of employment, it is seen that the wholesale and retail sector and service sector are expected to hire the largest number of employees in 1964 and 1975. This fact may be important to those who are responsible for the training of future employees in the state's educational institutions. The leaders of these institutions may desire to strengthen their educational program and expand the educational facili-

ties in the areas where the demand for future employment is the greatest.

Appendix A

Computation Procedure of the Income Multiplier

The underlying basis of the income multiplier is that a certain amount of income is generated with each change in output. A direct and indirect effect due to a change is distinguished in arriving at the income multiplier for each sector.

The direct income effect in the amount of each dollar of output which goes to households in the form of income either as wages or salaries, proprietor's income or rent income. The direct effect presented in Column (1) of Appendix Table I is the total of the three household rows presented in Table II.

The retail and wholesale sector has the largest direct income effect at 0.65 while the agricultural processing sector has the smallest direct effect at 0.17. The difference among the direct effects of the various sectors is largely the result of the nature of the sector. A labor intensive sector such as the retail and wholesale sector will spend more for wages and salaries than a capital intensive sector like the agricultural processing sector.

Indirect and direct income effects are the total changes in income as a result of the one dollar change in output. This effect is measured by considering how output in each sector changes as a result of an initial one dollar change in final demand and how the output change affects income. For example, from Table III, it can be seen that a dollar change in final demand for livestock products will change output in that sector by $1.31. Households receive as income $0.28 of every dollar change in output, therefore, an initial change will cause household income to change by $0.36. The initial change in final demand for livestock and livestock products of one dollar will cause a direct and indirect output change of $0.38 in the crop sector. From the direct effect, $0.56 of every dollar change in output in the crop sector goes to households. Thus household income changes by $0.21 as the result of the one dollar change in output of the livestock and livestock products sector. Similarly, the change in income as a result of the one dollar change in output in the livestock and livestock products sector can be computed for the remaining sectors. The sum of these income changes will give the total amount of direct and indirect income generated as a result of the initial one dollar change in final demand for that sector. The same procedure is used for each sector to compute the amount of the direct and indirect effects, which are listed in Column (2) of Appendix Table I.

The indirect income effect (Column 3) is obtained by subtracting the direct effect from the direct and indirect effect. The retail and wholesale sector has the lowest indirect effect and the agricultural processing sector has the highest indirect effect. The reason is that activity in the agricultural processing sector depends quite heavily on the other sectors in the economy. The activities of the agricultural processing sector depend largely on goods and services from the basic agricultural and manufacturing sectors. The livestock sector shows a large indirect effect mainly as a result of its dependence on the crop sector and on the agricultural processing sector for processed feed.

Income multipliers are listed in column (1) of Table VI. They are computed by dividing the direct and indirect effect by the direct effect (Column 2 ÷ Column 1). Each multiplier indicates the total amount of income generated by the increase of one dollar of income in that sector.

Appendix Table I. Direct and Indirect Effects Needed to Compute Income Multipliers

	Direct Income Effect (1)	Direct and Indirect Income Effect (2)	Indirect Income Effect (3)
Livestock and Livestock Products	.27739	.78028	.50289
Crops	.55862	.78426	.22564
Agricultural Processing	.16614	.71792	.55178
Manufacturing	.19957	.66911	.46954
Transportation, Communication and Public Utilities	.41977	.60536	.18609
Real Estate, Finance, and Insurance	.46672	.68365	.21693
Services	.48954	.77292	.28338
Wholesale and Retail	.64877	.83030	.18153
Mining	.47293	.74101	.26808

Appendix B

Computation Procedure of Employment Multiplier

The input-output employment multiplier is again related to a change in output. The change in output creates a direct and indirect effect. The direct employment effect indicates the number of men employed per

year per million dollars worth of output. These direct effects are listed in Column (1) of Appendix Table II. The direct employment effect of the agricultural processing sector indicates that 36.40 additional man-years of employment will be needed if final demand for that sector is increased by one million dollars. The service sector has the largest employment per million dollars' worth of output. This is because this sector produces personal services requiring large amounts of labor.

The direct and indirect effects are computed by considering the repercussions on employment in all the sectors as a result of the initial change in final demand in a sector. For example, a one million dollar increase in final demand will increase the output within the agricultural processing sector by 1.21 million dollars. This output increase will require 36.40 man-years of employment per million dollars increase in output. As a result of the initial increase in demand, the direct and indirect effect of the manufacturing sector will increase output by 0.21 million dollars. This sector requires 45.6 man-years of employment per million dollars worth of output. The total direct and indirect effect is obtained by summing up the additional man-years of employment needed by each sector as a result of the one million dollar increase in output

Appendix Table II. Direct and Indirect Effects Needed to Compute Income Multipliers

	Direct Effects (1)	Direct and Indirect Effects (2)	Indirect Effects (3)
		(Man-years)	
Livestock and Livestock Products	— *	—	—
Crops	— *	—	—
Agricultural Processing	36.402	102.701	66.299
Manufacturing	45.859	134.510	88.651
Transportation, Cummunication & Public Utilities	82.353	123.502	41.149
Finance, Real Estate and Insurance	82.621	127.954	45.333
Services	202.078	268.470	66.392
Wholesale and Retail	145.246	191.185	45.939
Mining	40.697	104.258	63.561

*Employment multiplier was not computed for sector.

of a particular sector. Column (2) of Appendix Table II shows these effects.

Subtracting Column (1) from Column (2) will yield the indirect effects. Manufacturing has the largest indirect effect, because of the large amount of interaction among industries in this sector and the other sectors. The indirect effects of the agricultural processing, mining and service sectors are somewhat similar.

The employment multipliers are devised by dividing the direct effect into the direct and indirect effect (Column 2 $\div$ Column 1). These multipliers are presented in Table VII.

Agriculture Boosts State Economy

Agriculture is the backbone of Oklahoma's economy. The state's agriculture is farms and ranches, to be sure, but it is also an ever-growing part of the city which supplies the tools to grow, process and distribute food and other farm products.

Agriculturally-related manufacturing, distributing and servicing industries are vital to Oklahoma's total economy.

The fertilizer industry is booming in Oklahoma. Over ten million acres of wheat, cotton, peanuts, sorghum and bermudagrass are fertilized in the state annually which requires over 400-thousand tons of bulk and bagged fertilizer. More than 700-thousand tons of additional fertilizer will be needed to supply the needs within the next decade.

Oklahoma farmers and ranchers are big users of petroleum products. They spend $30 - 40 million annually for gasoline, butane and propane, oils and greases.

Oklahoma's truck and equipment dealers also depend heavily upon agriculture. In 1963, more than $66-million dollars was spent by farmers and ranchers for trucks, tractors and related equipment.

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