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**Economic Structure and Income Redistribution:  
An Input-Output Perspective**

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# **Economic Structure and Income Redistribution:**

## **An Input-Output Perspective**

### **I. Introduction.**

Income distribution is considered by many to be an important indicator of the overall well-being or social condition of rural regions. Until relatively recently, however, rural development researchers and policymakers have not had convenient methods of assessing the distributional consequences of changes in economic structure. This paper presents a method of analyzing the distributional impacts of changes in sectoral output using an extended input-output model. An application of this method to a small resource-based region demonstrates that the distributional impacts of changes in sectoral output vary a great deal across sectors. These results provide information that could be useful in many aspects of development policy. Two important applications are the estimation of the distributional impacts of cyclical changes in regional output and the evaluation of development policies which are intended to attract specific industries into a region.

### **II. Income Redistribution in an Input-Output Model**

An Extended Input-Output Model. Until the past few years, the input-output models used in regional impact analysis included the household sector as a single, aggregated sector. Modelling households in this way precludes the analysis of income distribution issues. Recent advances in regional input-output modelling have transformed regional input-output models into useful tools for income distribution work (see, for example, Bernat and Johnson; Rose and Beaumont). All of these models are based on

Miyazawa's model of income distribution (Miyazawa) and can be expressed in the following way.

With  $n$  sectors in the region and households grouped into  $k$  income classes, sectoral output can be represented by the  $n \times 1$  vector  $x$  and household income by the  $k \times 1$  vector  $y$ . The regional balance equations can thus be represented by:

$$(1) \quad \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} A & C \\ V & 0 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} f \\ g \end{bmatrix}$$

The  $n \times n$  matrix  $A$  is the matrix of Leontief technical coefficients. The  $n \times k$  matrix  $C$  is composed of household consumption coefficients, each column being the vector of consumption coefficients for households in a given income group. The  $k \times n$  matrix  $V$  is composed of household value-added coefficients which indicate the sectoral value-added received by households in each income group. Finally, the vectors  $f$  ( $n \times 1$ ) and  $g$  ( $k \times 1$ ) represent final demand and exogenous household income, respectively.

Solving for regional output and income gives the familiar input-output formulation:

$$(2) \quad \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} I-A & -C \\ -V & I \end{bmatrix}^{-1} \begin{bmatrix} f \\ g \end{bmatrix}$$

The matrix  $\begin{bmatrix} I-A & -C \\ -V & I \end{bmatrix}^{-1}$  is the matrix of multipliers for this extended input-output model.

Because households are disaggregated into income classes, the multipliers derived from

this model can be used to indicate how changes in final demand and exogenous household income are likely to affect the income of households at different income levels. However, the model does not directly provide information regarding how relative incomes are likely to change. It indicates how the change in household income will be distributed across household groups but not how such changes will affect the relative distribution of income. Information on changes in the relative distribution of income can be gleaned from the above model using a method that has been developed in the context of social accounting matrices (SAM's).

Income Redistribution. Following Roland-Holst's work in the context of a SAM of the U.S. (Roland-Holst), a model of relative income redistribution can be formulated as the total differential of relative household income. If the vector of household income is defined to be a function of a vector of exogenous variables,  $z$ , relative income is:

$$(3) \quad y^* = f(z) [e'f(z)]^{-1}$$

where  $e'$  is the transpose of the unit vector. Taking the total differential of (3) with respect to the exogenous variables  $z$ :

$$(4) \quad dy^* = \{f'(z)[e'f(z)]^{-1} - f(z)[e'f'(z)][e'f(z)]^{-2}\} dz$$

where  $f'(z)$  is the differential of  $f(z)$  while  $e'$  is the transpose of the unit vector  $e$ .

Making use of the fact that  $[e'f(z)]^{-1}$  is a scalar, equation (4) can be rearranged to arrive at the matrix  $R$ , which Roland-Holst refers to as the redistribution matrix.

$$(5) \quad dy^* = (e'y)^{-1} [I - y^*e'] f'(z) dz = R dz$$

In essence, the redistribution matrix tells us how the income shares of each household group change as a result of changes in the exogenous variables  $f$  and  $g$ .  $R$  will have both positive and negative elements. Positive elements  $r_{ij}$  indicate that a unit increase in final demand for the  $j^{\text{th}}$  producing sector results in a relative increase in the  $i^{\text{th}}$  household group's income share. In other words, the household  $i$ 's share of the total household sector impact from a unit increase in sector  $j$ 's output exceeds the household group's initial share of income. By the same token, negative elements indicate a reduction in relative income shares. Because the column elements in each column indicate changes in relative shares, each column of  $R$  always sums to 0.

In the above input-output model, the exogenous variables are the vectors of final demand and exogenous household income. The function  $f(z)$  is:

$$(6) \quad f(z) = [B_{21} \quad B_{22}] \begin{bmatrix} f \\ g \end{bmatrix}$$

where  $B_{21}$  is the lower left-hand partition of the multiplier matrix in equation (2) which includes only the household rows and industry columns and  $B_{22}$  is the lower right-hand partition, made up of the household rows and household columns.

### III. Income Redistribution in a Coal Mining Region of Virginia

The above input-output model of income redistribution was applied to a small rural

region of Southwestern Virginia. The dominant industry in this economy is coal mining. The region has one of the least equal distributions of income in the State and, given the highly cyclical nature of the coal mining industry, exhibits wide fluctuations in household income (Kraybill, Johnson, and Deaton).

The input-output model was constructed using secondary sources. There are 57 producing sectors in the model, with households divided into 12 income classes (Bernat and Johnson). The redistribution matrix is therefore 12 x 69, with the first 57 columns indicating the redistributive effects of changes in sectoral final demand and the last 12 columns indicating the distributional impacts of changes in exogenous household income.

The pattern that emerges from the household portion of the extended input-output matrix ( $[B_{21} B_{22}]$ ) is that the multipliers are almost uniformly higher in the middle to upper-income groups than for households at either tail of the income spectrum.

However, it is not possible to tell just from this matrix how relative incomes would be affected. Table 1, a variation of the income redistribution matrix R, gives this information.

This variation was constructed from R by first dividing each element of R by total household income. The elements of the resulting matrix are interpreted as indicating the amount of income that must be redistributed among household groups to attain the new distribution of income while, at the same time, keeping total income unchanged from its

initial level. The sum of the positive elements in each column measures the total amount of income that is redistributed. To arrive at  $R^*$ , the matrix presented in Table 1, each element is divided by the total redistributed income for the column.

Each element of  $R^*$  thus gives the percent of the total redistributed income associated with a given household group. Thus, a value of 0.25 for the  $ij^{\text{th}}$  element indicates that the  $i^{\text{th}}$  household received 25 percent of the redistributed income for column  $j$ . If all households received exactly their original income share, no income would be redistributed and the elements would all be zero. If only one household group received an increase in income, its share of redistributed income would be 100 percent. As is the case with  $R$ , the elements of each column of  $R^*$  sum to 0.

The matrix exhibits a number of interesting features. First, the redistributive impacts for goods-producing sectors are relatively similar. In all cases, the three lowest income groups lose income share with increases in sectoral output. Furthermore, with the exceptions of agriculture and furniture manufacturing, the highest income group not only loses income share, but it absorbs the largest decline of any of the other losing household groups. Furniture manufacturing is an interesting anomaly in that two household groups receive all the relative income gains. More typically, 7 of the 12 household groups exhibit increases in income share. Exactly what makes the furniture sector so different is not clear.



For the service and utility sectors, the pattern exhibited so strongly by the goods producing sectors, with the highest income group and lowest three income groups exhibiting reductions in income shares, is not as uniform. Whereas the highest income group loses between 40 and 47 percent of the redistributed income in 21 of the 23 goods producing sectors, the range is between 59 percent of the loss (personal services) to 43 percent of the gain (social services). In fact, the highest income group gained share in 7 of the 34 service and utility sectors but this same group gained share in only one of the 23 producing sectors. Likewise the lowest three income groups generally lost share, but there were a number of sectors for which at least one of the three groups gained share. In miscellaneous retail, all three of the lowest income groups gained share, with the second and third lowest groups acquiring over 60 percent of the redistributed income.

#### **IV. Summary and Conclusions**

The finding that the middle and upper middle income groups experience gains in relative income as a result of increases in sectoral output is consistent with expectations, especially for the goods producing sectors. First, a large proportion of wages and salaries accrue to members of these households so that a large proportion of the household income generated by higher sectoral output is received by these households. Second, exogenous income is disproportionately distributed to the lower and upper income families. Lower income households receive a much higher proportion of public assistance payments and social security income. Similarly, the upper income households receive a disproportionate share of dividend, interest, and other exogenous capital-type

income. Thus, any increase in sectoral output will increase the share in total income of wage and salary component, leading to an increase in the share of total income of the households for which wage and salary income is the most important.

The less uniform pattern exhibited by the service sectors is more difficult to explain. Further work in this area is needed in order to decompose the various factors which contribute to the differences in redistribution across sectors. Such work would prove very valuable in improving our understanding of how changes in regional economic structure will affect the distribution of household income.

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Sector	Household Income (\$1,000)			
	< 10	10-21	21-52	52+
1 AGRICULTURE	-0.365	0.494	-0.260	0.132
2 METAL MINING	-0.528	0.553	0.419	-0.444
3 COAL MINING	-0.529	0.551	0.423	-0.445
4 OIL & GAS	-0.530	0.536	0.436	-0.442
5 NONMETAL MINING	-0.528	0.554	0.418	-0.444
6 GENERAL BLDG. CONTRACT	-0.486	0.509	0.421	-0.444
7 HEAVY CONST. CONTRACTO	-0.523	0.266	0.658	-0.401
8 SPECIAL TRADE CONTRACT	-0.510	0.392	0.553	-0.435
9 FOOD & KINDRED PROD.	-0.504	0.428	0.506	-0.430
10 APPAREL & OTHER PROD.	-0.522	0.572	0.408	-0.459
11 LUMBER & WOOD PROD.	-0.509	0.460	0.517	-0.468
12 FURNITURE & FIXTURES	-0.234	-0.431	0.786	-0.121
13 PRINTING & PUBLISHING	-0.528	0.556	0.413	-0.441
14 CHEMICALS	-0.503	0.578	0.381	-0.456
15 PETROLEUM & COAL	-0.425	0.518	0.330	-0.423
16 STONE, CLAY, & GLASS	-0.513	0.577	0.390	-0.454
17 PRIMARY METAL PROD.	-0.503	0.596	0.359	-0.452
18 FABRICATED METAL PROD.	-0.483	0.598	0.340	-0.456
19 MACHINERY	-0.519	0.518	0.457	-0.456
20 ELECTRIC EQUIP	-0.518	0.537	0.435	-0.454
21 TRANSPORTATION EQUIP.	-0.533	0.495	0.482	-0.443
22 INSTRUMENTS	-0.523	0.548	0.441	-0.466
23 MISC. MANUFACTURING	-0.471	0.453	0.473	-0.455
24 LOCAL PASS. TRANSIT	-0.390	0.342	0.293	-0.245
25 TRUCKING & WAREHOUSING	0.096	0.671	-0.562	-0.206
26 COMMUNICATION	-0.507	0.121	0.713	-0.327
27 UTILITIES	-0.532	0.326	0.577	-0.370

Sector	Household Income (\$1,000)			
	< 10	10-21	21-52	52+
28 WHLSALE-DURABLE-GOODS	-0.354	-0.369	0.926	-0.203
29 WHLSALE-NONDURABLE GOO	-0.498	0.448	0.418	-0.368
30 BLDG. MAT., GARDEN SUP	-0.463	0.522	0.403	-0.462
31 GENERAL MERCH. STORES	-0.283	0.762	0.033	-0.512
32 FOOD STORES	-0.102	0.671	-0.037	-0.532
33 AUTO. DEALERS, SERV.ST	-0.279	0.730	0.083	-0.534
34 APPAREL & ACCESS.STORE	-0.300	0.783	0.028	-0.510
35 FURNITURE	-0.044	0.605	-0.106	-0.455
36 EATING & DRINKING PLAC	-0.313	0.682	0.126	-0.495
37 MISCELLANEOUS RETAIL	0.677	0.156	-0.632	-0.202
38 BANKING	-0.220	0.740	0.002	-0.523
39 CREDIT AGENCIES	-0.370	-0.141	0.683	-0.171
40 SECURITY COMM. BROKER	-0.532	-0.255	0.769	0.018
41 INSURANCE CARRIERS	-0.526	-0.228	0.694	0.060
42 INS. AGENTS, BROKERS	-0.343	-0.001	0.532	-0.187
43 REAL ESTATE	-0.346	-0.001	0.556	-0.208
44 OTHER FINANCE	-0.343	0.393	0.330	-0.380
45 HOTELS & OTHER LODGING	-0.543	-0.281	0.571	0.254
46 PERSONAL SERVICES	0.288	0.618	-0.319	-0.587
47 BUSINESS SERVICES	-0.502	0.532	0.438	-0.468
48 AUTO REPAIR	-0.286	-0.084	0.719	-0.349
49 MISC. REPAIR SERVICES	-0.442	0.669	0.113	-0.340
50 MOTION PICTURES	-0.498	0.493	0.419	-0.414
51 AMUSEMENT & RECREATION	-0.373	0.349	0.408	-0.383
52 HEALTH SERVICES	-0.293	0.483	0.350	-0.540
53 LEGAL SERVICES	-0.195	0.249	0.205	-0.259
54 EDUCATIONAL SERVICES	-0.349	-0.386	0.511	0.224
55 SOCIAL SERVICES	-0.358	-0.252	0.182	0.428
56 MEMBERSHIP ORGANIZATIO	-0.196	-0.474	0.590	0.080
57 MISCELLANEOUS SERVICES	-0.187	-0.486	0.583	0.090
58 < \$6,360	0.900	-0.365	-0.457	-0.078
59 \$6,360 - \$8,479	0.871	-0.350	-0.439	-0.082
60 \$8,480 - \$10,599	0.898	-0.363	-0.454	-0.081
61 \$10,600 - \$12,719	-0.164	0.692	-0.449	-0.079
62 \$12,720 - \$14,839	-0.167	0.709	-0.460	-0.081
63 \$14,840 - \$16,959	-0.165	0.698	-0.454	-0.080
64 \$16,960 - \$21,198	-0.186	0.788	-0.512	-0.089
65 \$21,199 - \$25,439	-0.180	-0.398	0.665	-0.086
66 \$25,440 - \$31,799	-0.183	-0.405	0.675	-0.087
67 \$31,800 - \$42,399	-0.173	-0.384	0.639	-0.082
68 \$42,400 - \$52,999	-0.159	-0.354	0.588	-0.075
69 \$53,000 +	-0.166	-0.371	-0.463	1.000
SOCIAL SECURITY	0.900	-0.164	-0.596	-0.140
PUBLIC ASSISTANCE	0.900	-0.229	-0.532	-0.139
DIVIDENDS, ETC.	-0.225	-0.547	-0.066	0.838

TABLE 1 R\* (Transposed)

Producing Sectors	Household Classes											
	1	2	3	4	5	6	7	8	9	10	11	12
AGRICULTURE	-0.211	-0.090	-0.065	0.556	0.011	0.177	-0.250	-0.284	-0.010	-0.091	0.125	0.132
METAL MINING	-0.127	-0.140	-0.262	0.058	0.048	0.342	0.105	-0.028	0.164	0.121	0.161	-0.444
COAL MINING	-0.126	-0.140	-0.263	0.056	0.048	0.344	0.104	-0.026	0.161	0.125	0.163	-0.445
OIL & GAS	-0.129	-0.140	-0.261	0.069	0.039	0.334	0.094	-0.028	0.177	0.129	0.158	-0.442
NONMETAL MINING EX FUE	-0.126	-0.140	-0.262	0.059	0.045	0.343	0.107	-0.029	0.160	0.123	0.163	-0.444
GENERAL BLDG. CONTRACT	-0.130	-0.113	-0.243	0.086	0.003	0.374	0.045	-0.070	0.132	0.193	0.165	-0.444
HEAVY CONST. CONTRACTO	-0.169	-0.135	-0.219	0.043	-0.076	0.215	0.085	0.104	0.196	0.248	0.110	-0.401
SPECIAL TRADE CONTRACT	-0.154	-0.133	-0.224	0.068	-0.055	0.261	0.118	0.062	0.178	0.202	0.111	-0.435
FOOD & KINDRED PROD.	-0.161	-0.133	-0.211	0.097	-0.066	0.269	0.128	0.037	0.167	0.174	0.129	-0.430
APPAREL & OTHER PROD.	-0.132	-0.137	-0.253	0.097	0.021	0.335	0.119	-0.019	0.167	0.100	0.160	-0.459
LUMBER & WOOD PROD.	-0.146	-0.133	-0.229	0.114	-0.019	0.314	0.052	-0.004	0.190	0.184	0.147	-0.468
FURNITURE & FIXTURES	-0.090	-0.052	-0.092	-0.056	-0.102	-0.061	-0.212	-0.188	0.299	0.701	-0.026	-0.121
PRINTING & PUBLISHING	-0.128	-0.138	-0.262	0.058	0.047	0.341	0.110	-0.031	0.160	0.116	0.167	-0.441
CHEMICALS & ALLIED PRD	-0.140	-0.134	-0.229	0.119	-0.009	0.335	0.133	-0.032	0.142	0.116	0.155	-0.456
PETROLEUM & COAL PROD	-0.167	-0.073	-0.184	0.103	-0.050	0.364	0.101	-0.102	0.086	0.198	0.148	-0.423
STONE CLAY & GLASS	-0.136	-0.137	-0.240	0.093	0.016	0.337	0.131	-0.032	0.145	0.121	0.157	-0.454
PRIMARY METAL PROD.	-0.136	-0.142	-0.226	0.100	0.008	0.351	0.137	-0.045	0.122	0.127	0.154	-0.452
FABRICATED METAL PROD	-0.139	-0.135	-0.209	0.136	-0.023	0.334	0.152	-0.038	0.110	0.124	0.144	-0.456
MACHINERY EXCEPT ELEC	-0.147	-0.141	-0.230	0.103	-0.012	0.336	0.091	-0.013	0.141	0.177	0.151	-0.456
ELECTRIC & ELEC. EQUIP	-0.140	-0.137	-0.242	0.096	0.010	0.341	0.090	-0.028	0.150	0.155	0.158	-0.454
TRANSPORTATION EQUIP	-0.142	-0.137	-0.254	0.058	0.024	0.324	0.089	-0.024	0.153	0.198	0.155	-0.443
INSTRUMENTS & REL.PROD	-0.136	-0.137	-0.250	0.095	0.006	0.330	0.116	-0.010	0.162	0.139	0.150	-0.466
MISC. MANUFACTURING	-0.098	-0.148	-0.225	0.103	-0.048	0.314	0.085	-0.026	0.139	0.210	0.149	-0.455
LOCAL PASS. TRANSIT	-0.142	-0.209	-0.039	0.082	-0.186	0.196	0.250	-0.083	-0.096	0.383	0.089	-0.245
TRUCKING & WAREHOUSING	-0.054	0.009	0.142	0.305	-0.178	0.152	0.392	-0.204	-0.166	-0.168	-0.024	-0.206
COMMUNICATION (48)	-0.224	-0.109	-0.174	0.051	-0.060	0.235	-0.105	0.045	0.239	0.222	0.207	-0.327
ELEC. GAS&SANITARY SER	-0.223	-0.148	-0.161	0.109	-0.079	0.256	0.041	-0.018	0.185	0.232	0.178	-0.370
WHLSTALE-DURABLE-GOODS	-0.189	-0.073	-0.092	-0.042	-0.123	0.074	-0.277	0.142	0.028	0.710	0.046	-0.203
WHLSTALE-NONDURABLE GDS	-0.184	-0.107	-0.208	0.154	-0.076	0.318	0.052	-0.058	0.155	0.076	0.245	-0.368
BLDG. MAT.-GARDEN SUPP	-0.165	-0.107	-0.191	0.185	-0.059	0.331	0.066	-0.015	0.179	0.080	0.160	-0.462
GENERAL MERCH. STORES	-0.079	-0.076	-0.129	0.313	-0.120	0.411	0.158	-0.084	0.046	0.026	0.044	-0.512
FOOD STORES (54)	-0.083	0.110	-0.130	0.084	0.009	0.590	-0.012	-0.244	0.003	0.199	0.004	-0.532
AUTO. DEALERS-SERV.STA	-0.093	-0.078	-0.109	0.301	-0.096	0.414	0.111	-0.091	0.100	0.059	0.016	-0.534
APPAREL & ACCESS.STORE	-0.067	-0.099	-0.134	0.351	-0.130	0.375	0.186	-0.047	0.036	-0.013	0.051	-0.510
FURNITURE & HOME FURNI	-0.065	0.156	-0.135	0.004	0.016	0.591	-0.006	-0.261	-0.078	0.210	0.023	-0.455
EATING & DRINKING PLAC	-0.105	-0.066	-0.142	0.253	-0.101	0.405	0.125	-0.091	0.070	0.078	0.070	-0.495
MISCELLANEOUS RETAIL	0.066	0.259	0.352	0.151	0.086	0.087	-0.167	-0.190	-0.174	-0.235	-0.033	-0.202
BANKING (60)	-0.081	0.014	-0.153	0.232	-0.074	0.497	0.085	-0.169	0.029	0.096	0.047	-0.523
CREDIT AGENCIES EX.BAN	-0.276	-0.078	-0.017	-0.092	-0.038	0.221	-0.233	-0.096	0.241	0.418	0.120	-0.171
SECURITY COMM. BROKER	-0.397	-0.136	0.001	-0.126	-0.090	0.161	-0.200	-0.051	0.176	0.371	0.273	0.018
INSURANCE CARRIERS(63)	-0.337	-0.128	-0.061	-0.027	-0.094	0.091	-0.198	-0.155	0.281	0.381	0.188	0.060
INS. AGENTS BROKERS	-0.188	-0.071	-0.084	0.235	0.013	0.040	-0.289	-0.164	0.524	0.189	-0.017	-0.187
REAL ESTATE (65)	-0.166	-0.075	-0.105	0.327	-0.053	0.008	-0.284	-0.080	0.516	0.149	-0.029	-0.208
HOLDING-OTH. INV.. OFF	-0.165	-0.096	-0.082	0.391	-0.068	0.202	-0.132	-0.077	0.240	0.119	0.048	-0.380
HOTELS & OTHER LODGING	-0.315	-0.121	-0.107	-0.108	-0.125	0.037	-0.086	-0.138	0.014	0.393	0.302	0.254
PERSONAL SERVICES (72)	-0.083	0.148	0.223	0.307	-0.005	0.316	0.000	-0.168	-0.069	-0.088	0.006	-0.587
BUSINESS SERVICES (73)	-0.168	-0.120	-0.214	0.135	-0.016	0.370	0.042	-0.015	0.136	0.134	0.182	-0.468
AUTO REPAIR SERV.GARAG	-0.216	0.012	-0.083	0.107	-0.168	0.162	-0.184	0.053	0.141	0.253	0.271	-0.349
MISC. REPAIR SERVICES	-0.212	-0.188	-0.043	0.398	-0.052	0.219	0.104	-0.114	0.051	-0.052	0.228	-0.340
MOTION PICTURES (78)	-0.155	-0.159	-0.184	0.161	-0.073	0.307	0.098	-0.015	0.101	0.159	0.174	-0.414
AMUSEMENT & RECREATION	-0.277	0.010	-0.106	0.221	-0.035	0.362	-0.200	0.032	0.026	0.083	0.266	-0.383
HEALTH SERVICES (80)	-0.213	-0.051	-0.029	0.141	-0.068	0.318	0.092	-0.099	0.275	0.038	0.135	-0.540
LEGAL SERVICES (81)	-0.198	0.082	-0.078	0.254	-0.119	0.357	-0.243	-0.102	0.138	0.131	0.038	-0.259
EDUCATIONAL SERVICES	-0.236	-0.119	0.005	-0.100	-0.156	0.059	-0.189	-0.200	0.152	0.095	0.465	0.224
SOCIAL SERVICES (83)	-0.169	-0.060	-0.130	-0.094	-0.136	-0.047	0.025	-0.205	-0.160	0.542	0.005	0.428
MEMBERSHIP ORGANIZATN	0.056	-0.102	-0.150	0.072	-0.159	0.039	-0.427	-0.162	0.038	0.465	0.250	0.080
MISCELLANEOUS SERVICES	0.060	-0.100	-0.147	0.070	-0.158	0.034	-0.432	-0.163	0.034	0.465	0.248	0.090