Income Multipliers for Idaho

From IMPLAN Data

by

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A. E. Research Series, No. 91-6

May 1991

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Presented at an IMPLAN Workshop, St Paul, MN, May 20-22, 1991.

I. Do We Need to Check IMPLAN's Type III Multipliers?

Version 2.0, MicroIMPLAN, release 89-03 input-output software program developed by the USDA/Forest Service, provides type I and type III multipliers. MicroIMPLAN can provide these output, income, and employment multipliers for every state and county in the United States. Olson states that the IMPLAN type III algorithm is a "modification of the type III multiplier developed by Miernyk" and that the resulting type III multipliers "are typically five to fifteen percent smaller than the type II multipliers (Olson, p. 5-85)." As MicroIMPLAN becomes more widely adopted as the regional impact analysis program-of-choice, it becomes increasingly important to affirm the accuracy of the programs' equations and to assess their appropriateness. In this paper, an affirmation of the equations for the type III income multipliers is undertaken in the context of a 35 sector model of the state of Idaho.

The type III income multipliers are defined differently than type II multipliers. The crucial difference between the type III and the type II multipliers is the induced effects, which are based on different assumptions regarding the change in household consumption as incomes change. The household spending pattern of the type II induced effect is associated with the average propensity to consume (APC), based on new in-migrant households. Miernyk refers to this APC effect on income by new residents as the "population effect" (p. 109). The household spending pattern of the type III induced effect is associated with the marginal propensity to consume (MPC), and is associated with established residents or "per capita effect" (Miernyk, p. 109). According to Miller and Blair, "type III income multipliers ... are smaller, sector by sector, than the type II income multipliers (p. 110)." Therefore, the induced effects associated with type III multipliers (MPC) should be lower than the average of the induced effects associated with type II multipliers (APC) in every sector. Therefore, we would expect to find that IMPLAN type III total income multipliers to be less than their type II counterparts in every sector.

Two ways of checking the IMPLAN type III multipliers are used in this study. The first is to compare IMPLAN derived type III multipliers with a set of "hand calculated" type III's from the same data set. The second approach is to compare IMPLAN calculated type III multipliers with "hand calculated" type II multipliers.

II. The Two Sets of IMPLAN Type III Income Multipliers

There are two sets of type III total income multipliers that can be generated within the IMPLAN program. The first set of type III total income multipliers is found in "invert report 5.420" and are referred to here as the IMPLAN 5.420 multipliers. The second set of IMPLAN type III total income multipliers can be derived from the induced income information found in the impact report 6.223, referred to as the IMPLAN 6.223 multipliers. The IMPLAN 5.420 and 6.223 type III multipliers for Idaho are reported in table 1. These two sets of multipliers are not equal to each other. The 5.420 multipliers are less than the 6.223's in every sector.

III. Type I Income Multipliers

Before the type III multipliers can be hand calculated, it is necessary to be able to replicate the IMPLAN type I multipliers. The type I multipliers generated by the IMPLAN model for Idaho is presented in table 1. The type I multipliers are hand-calculated from the direct requirements table found in lister report 3.400. By using the IMPLAN data and the type I algorithm described by Miller and Blair, it was possible to replicate the IMPLAN type I income multipliers exactly (pp. 107-8).

IV. The Development of IMPLAN Type III Income Multipliers

The IMPLAN type III multipliers are developed inside of the IMPLAN (2.0) model. Olson describes the equations used to calculate type III induced effects as:

> ... IMPLAN first converts direct and indirect effects to changes in employment based on each sector's employment-to-output ratio. Employment change is then multiplied by the region's population-to-employment ratio, converting it into population change. Population change is multiplied by average regional per-capita consumption rates by the initial final demand changes. This change in household consumption is treated as additional final demand changes. These changes in final demand are multiplied by the Leontief matrix to generate the first round of induced (additional direct and indirect effects. The procedure is repeated, thereby capturing successive rounds of induced effects, until population change is less than 10 people. p. 5-86.

This procedure was translated into a set of equations and applied to the appropriate IMPLAN date for Idaho. The procedure itself is presented in nine steps in appendix 1.

By applying the iterative procedure in appendix 1, it became clear that the IMPLAN 5.420 multipliers do not repeat the iterations until the population change is less than ten. In fact the process is not repeated at all. In every sector, the actual population change associated with the IMPLAN type III induced effects is the simple employment multiplier multiplied by the population-to-employment ratio. See appendix 2. For the state of Idaho this ratio is 2.6. In every sector, this population change of the first round is not less than ten. The population changes range from 507 (wholesale trade) to 12 (real estate).

The iteration process is supposed to be repeated until the population is less than ten. The results of each round in the iteration process are then summed together to develop Impact reports. The type III income multipliers implied by the Impact Analysis reports may be found by making a one million dollar change in the final demand for the significant sector. The IMPLAN 6.223 multipliers define the induced effects for all rounds of the iteration process. These induced effects are then added to the direct and indirect effects of report 5.420 and then divided by the direct effects. The hand calculated type III multipliers were the same as the IMPLAN 5.420 multipliers after the first iteration and the same as the IMPLAN 6.223 multipliers after carrying out the appropriate number of iterations.

V. The Development of Type II Income Multipliers

The second approach of checking the IMPLAN type III multipliers is to compare them to hand calculated type II multipliers.

The type II multipliers build upon the direct requirements coefficients used to hand calculate the type I multipliers. The direct requirements matrix was "augmented" or "closed" with a household row and column as outlined in Miller and Blair (p. 108). The process of closing the input-output model, moves household consumption from a final demand column and household earnings from a value added row into the inter-industry transaction matrix as new industrial sector's row and column. Household earnings include employee compensation, proprietary income and other property income. This definition of earnings is consistent with IMPLAN direct income effects (Invert report #5.420) and the elements of the IMPLAN/M&B household row of the direct requirements coefficients matrix (for a closed economy).

The type II household income multiplier (Y_j^{II}) for sector j is found by the equation:

(1) $Y_j^{II} = \Sigma_i \, a_{n+1,i} \, \alpha'_{ij} / a_{n+1,j}$ $\qquad i=1,...,n+1$

where:

$a_{n+1,i}$ = the elements of the household input coefficients row in the direct requirements matrix (A),

α'_{ij} = the elements of the total requirements coefficients matrix $(I - A)'^{-1}$ for a closed model.

$a_{n+1,j}$ = the labor income effect of the initial dollar's worth of output.

The type II multipliers for 35 sector model of Idaho are reported in table 2. Theory suggests that type II multipliers should always be greater than type III multipliers. And yet, the type II multipliers are less than or equal to the IMPLAN 5.420 multipliers in six sectors and less than or equal to the IMPLAN 5.230 multipliers in thirteen sectors.

VI. Results

IMPLAN 5.420 multipliers are not consistent with the stated procedure for estimating type III induced effects in that it fails to go beyond a single iteration.

IMPLAN 6.223 multipliers are greater than or equal to type II multipliers for thirteen out of 35 sector of Idaho even though economic theory suggests that for a given change in income the MPC will be less that the APC. Therefore, the type III should always be less than the type II, sector by sector (Miernyk et al., pp. 110 & 116). The IMPLAN 6.223 multipliers were not 5 to 15% less than the type II multipliers as suggested by Olson but 3% more (p. 5-85). See table 2. Since this version of the MicroIMPLAN software does not generate type II multipliers, it is difficult to tell relationship between type II and the type III multipliers, for any given sector.

The means of calculating IMPLAN type III multipliers is based on a change in population. Miernyk et al. associate a change in population with a the APC and not the MPC (p. 109).

The IMPLAN type III procedure neither uses nor generates an intercept term, which is fundamental to the marginal propensity to consume concept.

VII. Warranted Assertions

The IMPLAN type III multipliers 5.420 and 6.223 are not type III multipliers but rather non-standard type II multipliers. We suggest that the "type III" multiplier be dropped from the IMPLAN model and replaced with a standard type II multiplier (Miller and Blair, pp. 107-9). At the very least, a type II multiplier should be include along with the "type III" multiplier.

Table 1. IMPLAN Type I and Type III Income Multipliers for Idaho.

Sector	IMPLAN 5.420 Type I	IMPLAN 5.420 Type III	IMPLAN 6.223 Type III
1 Agricultural products, and agriculture, forest and fishery services	1.5308	1.9914	2.1525
2 Mining	1.2524	1.5074	1.5966
3 New construction	1.4201	1.8545	2.0050
4 Maintenance and repair	1.1829	1.4775	1.5807
5 Fabricated metal products	1.1502	1.6055	1.7646
6 Food	2.3199	2.9383	3.1545
7 Textile mill products	1.1803	1.5041	1.5930
8 Apparel	1.1154	1.2515	1.2889
9 Lumber and wood products and furniture	1.5721	2.0602	2.2310
10 Paper and allied products	1.3683	1.6290	1.7004
11 Printing and publishing	1.2138	1.6486	1.8006
12 Chemicals and petroleum refining	1.5521	1.7429	1.7953
13 Rubber and leather products	1.4760	1.8715	2.0100
14 Stone, clay and glass products	1.4485	1.8627	2.0075
15 Primary metals industries	1.4553	1.7261	1.8005
16 Machinery except electrical	1.1221	1.3862	1.4786
17 Electric and electronic equipment	1.2740	1.5098	1.5744
18 Motor vehicles and equipment	1.2197	1.7381	1.9189
19 Transport equipment, not motor vehicles	3.3207	6.2558	7.2882
20 Instruments and related products	1.1463	1.4153	1.5093
21 Miscellaneous manufacturing industries	1.2393	1.6069	1.7355
22 Transportation	1.1896	1.4743	1.5723
23 Communication	1.0778	1.2413	1.2985
24 Electric, gas, water, and sanitary services	1.2139	1.3316	1.3641
25 Wholesale trade	1.2032	3.5276	4.3878
26 Retail trade	1.1867	1.6806	1.8533
27 Finance	1.1799	1.4809	1.5861
28 Insurance	1.7096	2.2601	2.4526
29 Real estate	1.1307	1.1769	1.1895
30 Hotels and lodging and amusements	1.4065	2.3869	2.7498
31 Personal services	1.1496	1.5405	1.6770
32 Business services	1.1395	1.3910	1.4790
33 Eating and drinking places	1.3671	2.1756	2.4579
34 Miscellaneous services	1.2261	1.6893	1.8511
35 Health services	1.2332	1.5729	1.6918

Table 2. Ratio of Type III to Type II Multipliers.

Sector	Type II	IMPLAN 5.420 Type III	Ratio 5.420/ Type II[1]	IMPLAN 6.223 Type III	Ratio 6.223/ Type II[2]
1 Agricultural products, and agriculture, forest and fishery services	2.1706	1.9914	.92	2.1525	.99
2 Mining	1.7759	1.5074	.85	1.5966	.90
3 New construction	2.0137	1.8545	.92	2.0050	1.00
4 Maintenance and repair	1.6774	1.4775	.88	1.5807	.94
5 Fabricated metal products	1.6309	1.6055	.98	1.7646	1.08
6 Food	3.2897	2.9383	.89	3.1545	.96
7 Textile mill products	1.6737	1.5041	.90	1.5930	.95
8 Apparel	1.5816	1.2515	.79	1.2889	.81
9 Lumber and wood products and furniture	2.2293	2.0602	.92	2.2310	1.00
10 Paper and allied products	1.9402	1.6290	.84	1.7004	.88
11 Printing and publishing	1.7212	1.6486	.96	1.8006	1.05
12 Chemicals and petroleum refining	2.2008	1.7429	.79	1.7953	.82
13 Rubber and leather products	2.0930	1.8715	.89	2.0100	.96
14 Stone, clay and glass products	2.0539	1.8627	.91	2.0075	.98
15 Primary metals industries	2.0636	1.7261	.84	1.8005	.87
16 Machinery except electrical	1.5912	1.3862	.87	1.4786	.93
17 Electric and electronic equipment	1.8066	1.5098	.84	1.5744	.87
18 Motor vehicles and equipment	1.7295	1.7381	1.01	1.9189	1.11
19 Transport equipment, not motor vehicles	4.7088	6.2558	1.33	7.2882	1.55
20 Instruments and related products	1.6254	1.4153	.87	1.5093	.93
21 Miscellaneous manufacturing industries	1.7573	1.6069	.91	1.7355	.99
22 Transportation	1.6868	1.4743	.87	1.5723	.93
23 Communication	1.5284	1.2413	.81	1.2985	.85
24 Electric, gas, water, and sanitary service	1.7213	1.3316	.77	1.3641	.79
25 Wholesale trade	1.7062	3.5276	2.07	4.3878	2.57
26 Retail trade	1.6827	1.6806	1.00	1.8533	1.10
27 Finance	1.6732	1.4809	.89	1.5861	.95
28 Insurance	2.4242	2.2601	.93	2.4526	1.01
29 Real estate	1.6033	1.1769	.73	1.1895	.74
30 Hotels and lodging and amusements	1.9944	2.3869	1.20	2.7498	1.38
31 Personal services	1.6301	1.5405	.95	1.6770	1.03
32 Business services	1.6159	1.3910	.86	1.4790	.92
33 Eating and drinking places	1.9386	2.1756	1.12	2.4579	1.27
34 Miscellaneous services	1.7387	1.6893	.97	1.8511	1.06
35 Health services	1.7487	1.5729	.90	1.6918	.97
Average			.95		1.03

[1] IMPLAN 5.420 multipliers divided by type II multipliers

[2] IMPLAN 6.223 multipliers divided by type II multipliers

References

Miernyk, William H. et al. Impact of the Space Program on a Local Economy. Morgantown, WV: West Virginia University Library, 1967.

Miller, Ronald E. and Peter D. Blair. Input-Output Analysis: Foundation and Extensions. Englewood Cliffs, NJ: Prentice-Hall, 1985.

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Appendix 1 Mathematical Steps to Generate IMPLAN Type III Multipliers

The following steps outline the IMPLAN mathematical process used to generate the induced effects for the type III income multipliers in a two sector economy.

Step 1: The initial change in the total output column vector ($\delta x^0{}_j$) is discover by multiplying the Leontief inverse matrix $(I\text{-}A)^{-1}$, from IMPLAN Invert report #5.2, by a change in final demand column vector (δY_i). The change in final demand is a column vector of zeros, except for the cell of the featured industry that is a one. This represents a one million dollar change in final demand for the featured industry, in this case sector 1.

$$\underset{(I\text{-}A)^{-1}}{\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}} \underset{(\delta Y_i)}{\begin{bmatrix} 1 \\ 0 \end{bmatrix}} = \underset{(\delta x^0{}_j)}{\begin{bmatrix} \delta x^0{}_1 \\ \delta x^0{}_2 \end{bmatrix}}$$

Step 2: The change in labor column vector (δw_j) is discovered by the multiplication a matrix of employment-to-output ratios on the diagonal $(E_i/X_i)^{\sim}$, from IMPLAN Lister reports #7.0 and #6.1 respectively, by the initial change in output column vector ($\delta x^0{}_j$).

$$\underset{(E_i/X_i)^{\sim}}{\begin{bmatrix} E_1/X_1 & 0 \\ 0 & E_2/X_2 \end{bmatrix}} \underset{(\delta x^0{}_j)}{\begin{bmatrix} \delta x^0{}_1 \\ \delta x^0{}_2 \end{bmatrix}} = \underset{(\delta e_j)}{\begin{bmatrix} \delta e_1 \\ \delta e_2 \end{bmatrix}}$$

Step 3: The column vector of changes in employment (δe_j) are column summed to produce a scalar of the total changes in labor (δE^T). This scalar of change in employment is also equal to the simple employment multiplier. See appendix 2.

$$\begin{bmatrix} \delta e_1 \\ \delta e_2 \end{bmatrix} \begin{bmatrix} 1 & 1 \end{bmatrix} = \begin{bmatrix} \delta E^T \end{bmatrix}$$

(δe_j)

Step 4: The scalar of the marginal population change (δP^T) is found by multiplying the total changes in labor (δE^T) by the ratio of population-to-total employment (P/E^T). Total employment data is from IMPLAN Lister report #7.0 and population data is from IMPLAN file ST_ID.DFD. The scalar of marginal population change is an important aspect of the IMPLAN model. The documentation of the IMPLAN model claims that the progression of these step is repeated until the population change is less than ten.

$$\begin{bmatrix} \delta E^T \end{bmatrix} \begin{bmatrix} P/E^T \end{bmatrix} = \begin{bmatrix} \delta P \end{bmatrix}$$

Step 5: The marginal change in regional household consumption column vector ($\delta H^C{}_j$) is generated by multiplying a column vector of a total household consumption-to-population ratios ($H_i{}^C/P$) by the marginal population change (δP). The household consumption data is from IMPLAN Lister report #6.0.

$$\begin{bmatrix} H^C{}_1/P \\ H^C{}_2/P \end{bmatrix} \begin{bmatrix} \delta P \end{bmatrix} = \begin{bmatrix} \delta H^C{}_1 \\ \delta H^C{}_2 \end{bmatrix}$$

$(H_i{}^C/P)$ $(\delta H^C{}_j)$

Step 6: The new change in total output ($\delta x^1{}_j$) is found by multiplying the Leontief inverse $(I-A)^{-1}$ by the marginal change of the regional household consumption column vector ($\delta H^C{}_j$).

$$\underset{(I-A)^{-1}}{\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}} \underset{(\delta H^C{}_j)}{\begin{bmatrix} \delta H^C{}_1 \\ \delta H^C{}_2 \end{bmatrix}} = \underset{(\delta x^1{}_j)}{\begin{bmatrix} \delta x^1{}_1 \\ \delta x^1{}_2 \end{bmatrix}}$$

Step 7: The process is repeated by replacing the by the initial change in output column vector ($\delta x^0{}_j$) of step 2 with the new change in total output ($\delta x^1{}_j$). According to the IMPLAN documentation, the process is repeated until the marginal population change of step 4 is less than ten.

$$\underset{(E_i/X_i)^{\sim}}{\begin{bmatrix} E_1/X_1 & 0 \\ 0 & E_2/X_2 \end{bmatrix}} \underset{(\delta x^1{}_j)}{\begin{bmatrix} \delta x^1{}_1 \\ \delta x^1{}_2 \end{bmatrix}} = \underset{(\delta e_j)}{\begin{bmatrix} \delta e_1 \\ \delta e_2 \end{bmatrix}}$$

Step 8: After the final round is generated, all of the rounds change in total output column vectors are summed together.

$$\begin{bmatrix} \delta x^1{}_1 \\ \delta x^1{}_2 \end{bmatrix} + \begin{bmatrix} \delta x^2{}_1 \\ \delta x^2{}_2 \end{bmatrix} + \ldots + \begin{bmatrix} \delta x^n{}_1 \\ \delta x^n{}_2 \end{bmatrix} = \begin{bmatrix} \Sigma_i \delta x_1 \\ \Sigma_i \delta x_2 \end{bmatrix}$$

Step 9: The summed column vectors of change in total output ($\Sigma_i \delta x_i$) is multiplied by the household direct requirements coefficiencts of a closed model to develop the type III induced effects for sector 1 ($INDY_1$).

$$\begin{bmatrix} \Sigma_i \delta x^n{}_1 \\ \Sigma_i \delta x^n{}_2 \end{bmatrix} \begin{bmatrix} a_{n+1,1} & a_{n+1,2} \end{bmatrix} = \begin{bmatrix} INDY_1 \end{bmatrix}$$

$$(\Sigma_i \delta x^n{}_j) \qquad (a_{n+1,i})$$

Appendix 2 Short Cut for Estimating IMPLAN 5.420 Type III Multipliers

The total changes in labor ($\delta W_j{}^T$) is also equal to the simple employment multiplier for the given sector. A short cut to the type III multiplier process can be made in every sector by inserting the simple employment multiplier (IMPLAN Invert report #5.440) for the given sector for ($\delta W_j{}^T$).

Employment multipliers estimate a relationship between the value of a sector's output delivered to final demand, and the physical employment used to produce that output. These employment multipliers are developed similarly to income multipliers.

The major difference between the income and employment multipliers is the use of physical labor input coefficients $w_{n+1,j}$, in place of the household input coefficients $a_{n+1,j}$. Employment multipliers use the physical labor input coefficients ($w_{n+1,i}$), which can be found from the equation:

(11) $w_{n+1,i} = e_i / X_i$.

where:

e_i = the number of employees in sector i,

X_i = the total output for sector i.

This equation determines the number of employees per dollar of output (Miller and Blair, p. 111).

The simple employment multiplier interprets the impact of final demand changes into changes of physical employment. The simple employment multiplier (E_j^s) is reported in IMPLAN file #606 and is found by the equation:

(12) $E_j^s = \Sigma_i w_{n+1,i} \alpha_{ij}$ $\quad$ $i = 1,\ldots,n.$

where:

$w_{n+1,i}$ = the elements of the physical labor input coefficients row,

α_{ij} = the elements of the total requirements coefficients matrix $(I-A)^{-1}$ for an open model.

Each element in the physical labor input coefficients row indicates the number of employees per dollar's worth of sectorial output. Each element in the total requirements coefficients matrix $(I-A)^{-1}$ measures the value of direct and indirect output effects (Miller and Blair, p. 111).