A SYSTEMATIC COMPARISON OF THE REMI AND IMPLAN MODELS: THE CASE OF SOUTHERN NEVADA

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Abstract–Despite the growing popularity of ready-made, regional economic impact models, few performance comparisons of the available models exist. Most studies have either examined the general characteristics and usability of the models or presented a specific application of a model. This paper systematically compares the performance of the two most widely used models: REMI and IMPLAN. A recent comparison of REMI and IMPLAN contained methodological errors that precluded a systematic evaluation. The areas used in the comparison in this paper are one urban county and two rural counties in southern Nevada. In addition to presenting the comparison of REMI and IMPLAN, this paper discusses the general applicability of the comparison to other models and establishes criteria that could be used in future comparisons of regional economic impact models.

I. INTRODUCTION

Despite the growing popularity of ready-made regional economic impact models among practitioners, few articles exist that compare the performance of the models. To be sure, most articles have examined the characteristics of alternative ready-made models and their ease of use or presented a specific application of a model (Bergstrom et al. 1990; Brucker et al. 1987; Kluender et al. 1991; Lieu 1991; Radtke et al. 1985; Sivitandou and Polenske 1988). A notable exception is the study by Brucker et al. (1990), which surveyed predictions from five regional input-output models and a survey model for seven hypothetical regional development scenarios. Surprisingly, no systematic study of the two most widely used regional economic impact models, REMI and IMPLAN (Burress et al. 1988), exists.[1] This is particularly important because the REMI and IMPLAN models differ significantly in cost and ease of use. One would expect purchasers to seek comprehensive model performance evaluations.

In the only previous comparison of REMI and IMPLAN, Crihfield and Campbell (1991) estimate the impacts of opening an automobile assembly plant in central Illinois. Based on their evaluation, they conclude that "IMPLAN's outcomes, on balance, are somewhat more plausible than those for REMI." However,

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in a comment on their paper, Grimes et al. (1992) conclude that Crihfield and Campbell "did not carry out comparable experiments with the two models, and had they done so, the outcome comparisons would have shown completely different results, and would have led to different conclusions." The primary problem of the Crihfield and Campbell study is that identical industry definitions were not used in the simulations of each model. Motor Vehicles and Car Bodies (S.I.C. 3711) was used in the REMI model simulation, and the more aggregate category, Motor Vehicles and Equipment (S.I.C. 371), was used in the simulation of the IMPLAN model. As Grimes et al. note, because it includes automobile assembly plants, the quantity of purchased materials and economic impact is greater for S.I.C. 3711 than the remaining components of S.I.C. 371.

In addition to not using identical industry definitions, the methodology of Crihfield and Campbell does not allow for definite conclusions to be drawn about systematic differences between the models. First, the multipliers of all the major industries of an economy should be compared as opposed to using just a single industry. The similarity or difference of one industry's multiplier does not reveal much about systematic differences in the two models. Second, the models should be standardized to obtain conceptually equivalent multipliers. This is particularly important when using the REMI model because of its complexity.

Therefore, this paper systematically compares the performance of the IMPLAN and REMI models, in this case using the southern Nevada region. The next section presents brief descriptions of the REMI and IMPLAN models. Also, this section discusses how the models are standardized for comparison. In the third section, the models are compared for the major sectors of one primarily urban county (Clark), which includes Las Vegas, and two rural counties (Nye and Lincoln). Finally, the conclusion contains a summary of the findings, a discussion of the general applicability of the results, and criteria that could be used in future comparisons of regional economic impact models.

II. REMI AND IMPLAN MODELS OF SOUTHERN NEVADA

Overview

The REMI model is developed by Regional Economic Models, Inc. of Amherst, Massachusetts (Treyz, Rickman, and Shao 1992). Specifically, the REMI model used in this study is the 1991 EDFS-53 multiregional version, which contains five regions: Clark County, Nye County, Lincoln County, Washoe County, and the remainder of Nevada. The REMI model specifies commodity-trade and personal-income flows between the regions. Production is categorized into 49

nonfarm private industries (primarily at the two-digit S.I.C. level), three government sectors, and the farm sector. Economic relationships are given by an industry-based input-output component combined with an econometric component. Also, the model is dynamic, which allows it to be used for forecasting in addition to use as an impact model.

IMPLAN, an input-output model, was developed by the Forest Service of the U.S. Department of Agriculture (U.S. Forest Service 1989). For this study, the 1985 IMPLAN version is used. Each of the counties studied is modeled as a single region without economic links to the other regions. The greatest level of disaggregation of the model is 528 sectors. However, the industries that do not exist in the region are automatically eliminated during user construction of the model. In addition, industries of the IMPLAN model can be aggregated into desired categories. Therefore, the industries of the IMPLAN model are aggregated to match the industry classifications of the REMI model. Also, IMPLAN uses an industry-based technology to derive its input-output coefficients. Finally, IMPLAN is a static model and cannot trace the time path of economic impacts or be readily used for forecasting.

REMI Model

The REMI model, as Bolton (1985) states in his review of econometric models, "is a world apart in complexity, reliance on interindustry linkages, and modeling philosophy" from other econometric models. The REMI model is more than an econometric model, though. It may better be described as an eclectic model that links an input-output model to an econometric model. If the econometric responses are suppressed, the model collapses to an input-output model. The econometric specifications are derived from economic theories that are generally neoclassical in nature. The notion of regional equilibrium is central to the model's long-term portrait of regional economic growth.

Although a detailed description of the model is impossible within the scope of the present study, an outline of the basic structure facilitates the evaluation of model performance. Conceptually, the model consists of five basic blocks: (1) output, (2) labor and capital demands, (3) population and labor supply, (4) wages, prices, and profits, and (5) market shares.

The output block contains the input-output component of the model. Final demands drive the output block. Production uses factor inputs, labor, capital and fuel, and intermediate inputs. Coefficients of the production functions are based on national input-output tables produced by the Bureau of Labor Statistics. Intermediate inputs are used in fixed proportions. Factor input use is governed by Cobb-Douglas functions in Block 2. Thus, in contrast to input-output models,

such as IMPLAN, the relative factor intensities respond to changes in relative factor costs (i.e, wage rate changes, cost-of-capital changes, and changes in fuel prices).

Labor supply in Block 3 responds positively to wage rates because of migration. Also, the ratio of residence-adjusted employment to the potential labor force influences migration. Place-of-work income also is adjusted for place of residence to obtain disposable income. The interaction of labor demand calculated in Block 2 and of labor supply calculated in Block 3 determines wage rates in Block 4. Migration induces government spending through additional taxes paid and consumer spending through increased wage and nonwage income. The increase in real disposable income derived from migration also stimulates residential investment. Nonresidential investment is stimulated by increased capital demand by businesses.

Wage rates affect the competitiveness of local firms relative to firms in other regions in Block 5. Regional competitiveness affects the shares of local and export markets (market shares) that local firms capture. The proportion of the local market captured is known as the regional purchase coefficient (RPC), and the proportion of the export market is known as the interregional and international coefficient. Also, the RPC, which is a measure of self-sufficiency, increases as a region grows because of agglomeration effects.

Endogenous consumption, investment, and government expenditures plus exports are the final demands that drive the output block. The endogenous RPC gives the proportions of local expenditures satisfied by imports or local production. Solution values for the endogenous variables in the REMI model must satisfy the equations in all five blocks simultaneously.

By suppressing certain endogenous responses in the REMI model, multipliers comparable to those computed from an input-output model can be obtained. If the responses of labor intensities, labor supply, wage rates, industry RPC's, and endogenous final demands are suppressed, Type I input-output multipliers are obtained. By allowing consumption to be endogenously determined, Type II multipliers are obtained. Complete endogeneity in the REMI model produces what is referred to as Type III multipliers. This Type III multiplier differs from standard Type III input-output multipliers because of the endogeneity of export and propensity to import responses in the REMI model.

The detailed structure of the REMI model requires an extensive amount of data. The input-output component is nonsurvey based, using national technical coefficients. Of particular importance are data on employment, income, and output. Also, because complete regional accounts consistent with the National Income and Product Accounts are not routinely available, they must be constructed.

REMI uses three sources of employment and wage and salary data: the Bureau of Economic Analysis (BEA) employment, wage, and personal income series, ES-202 establishment employment and wage and salary data, and County Business Patterns (CBP) data published by the Bureau of the Census. The BEA data are annual averages and are reported at the two-digit level for states and at the one-digit level for counties. The ES-202 data, the foundation for the BEA data, are collected monthly in conjunction with the unemployment insurance program at the two-digit level for counties and states, and they are the foundation for the BEA data. CBP data are collected in conjunction with the Social Security program in March of each year.

Confidentiality requirements produce many suppressions in the data. Where suppressions occur, the number of establishments and the ranges of the number of employees for each establishment are supplied by CBP. REMI fills in the suppressions based on the hierarchical structure of the BEA data within regions and within industries. First, all two-digit S.I.C. industries are made consistent within the corresponding one-digit industries for each state simultaneous with all two-digit industries summed to the major region two-digit totals. Second, for counties REMI uses the ES-202 data, if available, and CBP data if ES-202 data is not

TABLE 1
Industry Classification Scheme

REMI Sector	1977 S.I.C. Code
Amusement and recreation services	79
Auto repair, services, and garages	75
Communication	48
Construction	15 – 17
Eating and drinking places	58
Farm	01 – 02
Hotels and lodging places	70
Legal and miscellaneous services	81, 89 (except 892)
Medical and other health services	80
Mining	10 – 14
Miscellaneous business services	73
Motion pictures	78
Nonprofit membership organizations	83, 84, 86, 892
Other retail trade	52 – 57, 59
Personal services	72, 76
Real estate	64, 69
Wholesale trade	50 –51

available. Whichever data set is selected, it is made consistent with BEA one-digit county totals and state two-digit totals.

Output measures are based on regional employment data, the BEA Gross State Product series, and national output-to-employment ratios. REMI begins by applying the national output-to-employee ratio to employment by industry. This application is adjusted by regional differences in labor intensity and total factor productivity. Regional differences in labor intensity are given by the industry production function and the unit factor costs. Total factor productivity calculations depend on industry value added in production reported in real U.S. dollars by BEA and on adjustments by REMI to the BEA numbers to reflect differences in regional production costs. The ratio of real regional value added per unit of input relative to U.S. value added per unit of input is the REMI relative total factor productivity.

IMPLAN Model

In contrast to REMI, IMPLAN is exclusively an input-output model. It is nonsurvey based, and its structure typifies that of input-output models found in the regional science literature. Similar to REMI, IMPLAN assumes a uniform national production technology and uses the regional purchase coefficient approach to regionalize the technical coefficients.

The model generates two types of multipliers: Type I multipliers and what IMPLAN refers to as Type III multipliers. The difference between IMPLAN's Type I and Type III multipliers is an induced consumption effect. Their Type III multiplier differs from the standard Type II multiplier because the consumption function is nonlinear; that is, the marginal propensity to consume is not constant, decreasing as income in the region rises.[2] Population completely responds to employment changes and drives consumer spending. Multipliers are generated for employment, output, value added, personal income, and total income.

Similar to REMI, IMPLAN builds its data from top to bottom. National data serve as control totals for state data. In turn, state data serve as control totals for county data. The primary sources of employment and earnings data are County Business Patterns data and BEA data. Furthermore, IMPLAN's procedure for filling in suppressions in the 1985 model parallels REMI's, except the ES-202 data set is not a primary source of data for counties.

IMPLAN estimates output at the state level by using value added reported by BEA as proxies to allocate U.S. total gross output. Also, IMPLAN allocates state total gross output to counties based on county employment earnings. The use of the BEA Gross State Product series for states, and implicit assumption of uniform value added-to-earnings ratios across counties within a state, parallels REMI's

procedure. However, because of REMI's neoclassical production function, differential labor costs cause REMI's labor intensities to differ across states and counties. In addition, REMI adjusts real value added in U.S. dollars reported by BEA for differences in regional unit factor costs.

III. RESULTS OF MODEL COMPARISONS

Employment and output multipliers produced by the IMPLAN and REMI models for the major private industries are compared for Clark, Nye, and Lincoln counties in Nevada.[3] The three counties are contiguous to each other. Since Clark County contains Las Vegas, its economy is largely urban. Nye and Lincoln counties are small and rural. The urban-rural dichotomy of the three counties provides a broad-based setting for the comparison of the two models. Also, the Nevada Test Site (NTS), which is part of the Department of Energy's nuclear weapons testing program, is located in the rural counties. Most of the associated economic activity, however, is located in Nye County. This provides additional insights into the ability of the models to capture the features of economies with special government installations.

According to both models, nine industries account for almost 80 percent of private employment in Clark County. Both models agree on which industries are the largest employers in the county. However, considerable disagreement emerges about the composition of the largest industries contained in the two models for Nye and Lincoln counties. The number of industries selected for Nye and Lincoln counties are 14 and 11, respectively, accounting for more than 90 percent of total private employment in each county.

Being nonstochastic, input-output models cannot be simply evaluated by their *ex ante* forecasting accuracy as is typical with stochastic models. Moreover, since survey-based input-output models do not exist for southern Nevada, direct comparisons of the multipliers to a baseline also are not possible. Besides, even if they were available for southern Nevada, survey-based models are not necessarily superior to nonsurvey-based models because of potential problems with the survey methodology. Therefore, the models are evaluated by comparing them to each other.

Examination of the documentation of the REMI and IMPLAN models reveals structural differences. However, these differences may not significantly affect the multiplier estimates. On the other hand, if estimated differences are found to be significant, the underlying assumptions and methods that cause the differences can be evaluated for their appropriateness.

Type I, II, and III employment and output multipliers from the REMI and IMPLAN models are compared for Clark, Nye, and Lincoln counties.[4] In this study, IMPLAN's Type III multipliers are referred to as Type II multipliers because the general difference between Type I and Type II multipliers is an induced-consumption effect. REMI's complete model response is labelled Type III because it includes induced investment expenditures, government expenditures, and endogenous export and propensity to import responses. No comparable multiplier is available in the IMPLAN model.

Also, statistical tests are performed for differences in the multipliers and correlations between the multipliers. The parametric matched t-test and two nonparametric tests (Sign and Wilcoxon) are used to determine the statistical significance of multiplier differences.[5] Even if statistical differences exist, the multipliers may be correlated. That is, all multipliers of one model may be smaller (or larger) than those of the other model. But, do the larger and smaller multipliers occur in the same industries in both models? The answer is useful in determining the relative importance of industries to a regional economy. Both the parametric correlation coefficient and nonparametric Spearman's Rank correlation coefficient are calculated.[6]

As shown in Table 2, the employment and output multipliers of the two models for Clark County show different statistical properties. Across industries, the Type I employment multipliers of REMI and IMPLAN are significantly correlated. Yet, the three tests (Matched t, Wilcoxon, and Sign) indicate significant differences between the Type I employment multipliers. On the other hand, the Type I output multipliers are statistically different and are not significantly correlated. The Type II employment multipliers of the two models are significantly correlated and do not differ. Type II output multipliers both differ and are not correlated. The Type III REMI employment multipliers are larger than IMPLAN's Type II multipliers, but they are correlated. REMI's Type III output multipliers are neither significantly different nor correlated with IMPLAN's Type II multipliers.

The multipliers for the rural counties also generally differ. All multipliers for Nye County (Table 3), except for Type I employment multipliers, are significantly different in the two models. The IMPLAN multipliers are generally larger. Yet, all employment multipliers are significantly correlated. All employment and output multipliers for Lincoln County (Table 4) significantly differ. Only the Type II employment multipliers are significantly correlated.

An explanation of the results requires discussion of the structures of the two models. Since BEA national technical coefficients are used in both models, differences in the multipliers stem primarily from differences in the regional purchase coefficients (RPC's) (Stevens et al. 1989). As Table 5 shows, IMPLAN's

TABLE 2
Clark County Multiplier Comparisons

	Employment Multipliers					Output Multipliers				
	Type I		Type II		Type III	Type I		Type II		Type III
Sector	IMPLAN	REMI	IMPLAN	REMI	REMI	IMPLAN	REMI	IMPLAN	REMI	REMI
Col. Number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Amusement and recreation	1.22	1.22	1.39	1.43	1.69	1.23	1.30	1.64	1.57	1.97
Construction	1.48	1.46	1.69	1.82	2.26	1.31	1.19	1.67	1.35	1.56
Eating and drinking	1.15	1.10	1.31	1.21	1.35	1.26	1.19	1.88	1.38	1.66
Hotel	1.21	1.18	1.38	1.42	1.75	1.29	1.23	1.80	1.50	1.92
Medical	1.22	1.14	1.38	1.45	1.75	1.27	1.19	1.71	1.53	1.95
Miscellaneous business services	1.17	1.12	1.33	1.30	1.43	1.23	1.19	1.79	1.50	1.82
Miscellaneous professional services	1.26	1.15	1.43	1.45	1.69	1.29	1.23	1.80	1.69	2.17
Other retail	1.35	1.28	1.53	1.42	1.51	1.33	1.24	1.91	1.51	1.91
Real estate	1.21	1.14	1.38	1.31	1.51	1.24	1.16	1.50	1.21	1.55
Statistics	Column (1) vs. (2)		Column (3) vs. (4)		Column (5) vs. (3)	Column (6) vs. (7)		Column (8) vs. (9)		Column (10) vs. (8)
Correlation	0.96*		0.90*		0.79*	0.05		0.49		0.39
Spearman's Rank	0.86*		0.78*		0.59*	0.22		0.24		0.21
Matched t-test Sig.	0.00		0.97		0.01	0.01		0.00		0.21
Wilcoxon Test Sig.	0.01		1.00		0.01	0.03		0.00		0.59
Sign Test Sig.	0.01		1.00		0.01	0.04		0.00		0.26

* Denotes significant at or below the 0.01 level.
** Denotes significant at or below the 0.05 level.
*** Denotes significant at or below the 0.10 level.

TABLE 3
Nye County Multiplier Comparisons

	Employment Multipliers					Output Multipliers				
	Type I		Type II		Type III	Type I		Type II		Type III
Sector	IMPLAN	REMI	IMPLAN	REMI	REMI	IMPLAN	REMI	IMPLAN	REMI	REMI
Col. Number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Amusement and recreation	1.11	1.06	1.16	1.09	1.08	1.12	1.12	1.21	1.19	1.10
Communications	1.15	1.13	1.19	1.16	1.08	1.11	1.07	1.18	1.09	1.08
Construction	1.18	1.22	1.23	1.25	1.13	1.10	1.09	1.18	1.11	0.98
Eating and drinking	1.05	1.03	1.09	1.06	1.08	1.08	1.08	1.22	1.13	1.09
Farm	1.24	1.08	1.29	1.13	1.19	1.26	1.06	1.34	1.09	1.08
Hotel	1.09	1.06	1.13	1.09	1.08	1.13	1.10	1.25	1.15	1.11
Mining	1.17	1.18	1.21	1.22	1.21	1.19	1.10	1.26	1.11	1.12
Miscellaneous business services	1.08	1.07	1.12	1.10	1.08	1.11	1.08	1.24	1.13	1.07
Miscellaneous professional services	1.12	1.09	1.16	1.12	0.97	1.15	1.14	1.28	1.21	0.98
Nonprofit	1.05	1.05	1.10	1.08	1.03	1.14	1.14	1.38	1.19	1.08
Other retail	1.10	1.07	1.15	1.10	1.09	1.16	1.15	1.29	1.21	1.15
Personal service	1.02	1.03	1.07	1.05	1.07	1.07	1.10	1.32	1.16	1.12
Real estate	1.16	1.15	1.20	1.19	1.32	1.10	1.07	1.16	1.10	1.15
Wholesale	1.15	1.18	1.19	1.21	1.13	1.13	1.13	1.22	1.16	1.11
Statistics	Column (1) vs. (2)		Column (3) vs. (4)		Column (5) vs. (3)	Column (6) vs. (7)		Column (8) vs. (9)		Column (10) vs. (8)
Correlation	0.69*		0.73*		0.57**	0.06		0.41		0.04
Spearman's Rank	0.86*		0.89*		0.75*	0.35		0.41		0.00
Matched t-test Sig.	0.15		0.02		0.01	0.06		0.00		0.00
Wilcoxon Test Sig.	0.14		0.01		0.03	0.02		0.00		0.00
Sign Test Sig.	0.27		0.06		0.01	0.02		0.00		0.00

* Denotes significant at or below the 0.01 level.
** Denotes significant at or below the 0.05 level.
*** Denotes significant at or below the 0.10 level.

TABLE 4
Lincoln County Multiplier Comparisons

	Employment Multipliers					Output Multipliers				
	Type I		Type II		Type III	Type I		Type II		Type III
Sector	IMPLAN	REMI	IMPLAN	REMI	REMI	IMPLAN	REMI	IMPLAN	REMI	REMI
Col. Number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Auto. repair	1.16	1.03	1.24	1.07	1.15	1.13	1.03	1.24	1.05	1.05
Communications	1.11	1.09	1.19	1.13	1.03	1.07	1.05	1.16	1.06	1.06
Eating and drinking	1.06	1.01	1.13	1.04	1.12	1.09	1.02	1.28	1.07	1.05
Farm	1.23	1.01	1.31	1.06	1.23	1.23	1.00	1.34	1.03	1.04
Hotel	1.10	1.02	1.17	1.05	1.06	1.14	1.04	1.29	1.05	1.06
Medical	1.07	1.03	1.14	1.05	0.97	1.06	1.04	1.15	1.05	0.99
Mining	1.15	1.08	1.22	1.12	1.11	1.17	1.05	1.28	1.07	1.09
Miscellaneous business services	1.02	1.03	1.08	1.06	1.17	1.07	1.03	1.53	1.06	1.05
Motion pictures	1.71	1.08	1.82	1.12	1.03	1.77	1.11	2.04	1.15	1.03
Nonprofit	1.10	1.02	1.17	1.05	1.09	1.18	1.03	1.40	1.08	1.04
Other retail	1.11	1.02	1.18	1.05	1.10	1.15	1.06	1.32	1.09	1.07
Statistics	Column (1) vs. (2)		Column (3) vs. (4)		Column (5) vs. (3)	Column (6) vs. (7)		Column (8) vs. (9)		Column (10) vs. (8)
Correlation	0.46		0.52***		-0.17	0.73*		0.80*		-0.12
Spearman's Rank	0.25		0.66**		0.01	0.13		0.49		-0.19
Matched t-test Sig.	0.04		0.01		0.06	0.02		0.00		0.00
Wilcoxon Test Sig.	0.00		0.00		0.01	0.00		0.00		0.00
Sign Test Sig.	0.01		0.00		0.01	0.00		0.00		0.00

* Denotes significant at or below the 0.01 level.
** Denotes significant at or below the 0.05 level.
*** Denotes significant at or below the 0.10 level.

TABLE 5
Regional Purchase Coefficient Comparisons

	Clark		Nye				Lincoln			
	Model		Model		Survey		Model		Survey	
Sector	REMI	IMPLAN	REMI	IMPLAN	REMI	IMPLAN	REMI	IMPLAN	REMI	IMPLAN
Col. Number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Amusement and recreation	0.61	0.99	0.08	1.00	1.00	0.37	NA	NA	NA	NA
Automotive repair	NA	NA	NA	NA	NA	NA	0.00	1.00	0.00	0.00
Communications	NA	NA	0.10	1.00	0.04	0.30	0.65	1.00	0.16	0.19
Construction	0.84	0.91	0.13	0.94	0.68	0.86	NA	NA	NA	NA
Eating and drinking	0.84	1.00	0.10	0.56	0.09	0.56	0.39	0.91	0.51	0.79
Hotel	0.58	1.00	0.02	1.00	0.64	1.00	0.00	1.00	0.08	1.00
Medical	0.76	0.76	NA	NA	NA	NA	0.05	1.00	0.00	0.00
Mining	NA	NA	0.46	0.51	1.00	1.00	0.71	0.31	1.00	1.00
Miscellaneous business services	0.65	0.86	0.65	1.00	1.00	1.00	0.07	1.00	1.00	1.00
Miscellaneous professional services	0.69	0.88	0.67	0.42	1.00	0.31	NA	NA	NA	NA
Motion pictures	NA	NA	NA	NA	NA	NA	0.38	1.00	0.00	0.00
Nonprofit	NA	NA	0.14	0.92	0.00	0.00	0.27	1.00	0.00	0.00
Other retail	0.88	1.00	0.25	0.50	0.23	0.42	0.39	0.81	0.26	0.21
Personnel services	NA	NA	0.06	1.00	0.08	1.00	NA	NA	NA	NA
Real estate	0.86	0.82	0.87	0.24	0.95	0.14	NA	NA	NA	NA
Wholesale	NA	NA	0.06	0.14	0.06	0.10	NA	NA	NA	NA
Statistics	Column (1) vs. (2)		Column (3) vs. (4)		Column (5) vs. (6)		Column (7) vs. (8)		Column (9) vs. (10)	
Correlation	-0.13		-0.43		0.30		-0.61**		0.71**	
Spearman's Rank	-0.04		-0.44		0.43		-0.68**		0.86*	
Matched t-test Sig.	-0.01		0.01		0.87		0.00		0.24	
Wilcoxon Test Sig.	0.02		0.01		0.72		0.01		0.38	
Sign Test Sig.	0.07		0.02		0.34		0.04		0.63	

*Denotes significant at or below the 0.01 level. **Denotes significant at or below the 0.05 level. ***Denotes significant at or below the 0.10 level.
NA Denotes not applicable

RPC's are significantly larger in all three counties, which explains the larger Type I and Type II IMPLAN multipliers. Moreover, the RPC's are negatively correlated, but only significantly so for Lincoln County. This contributes to the insignificant correlations of the output multipliers.

In spite of insignificant corresponding output multipliers, the significant correlations of Type I and II employment multipliers are explained by industry variations in wage rates. Industries with higher wage rates have larger employment impacts. For example, an exogenous increase in employment in construction is associated with a greater amount of wage income than the same employment increase in retail, producing larger employment impacts in the regional economy. Therefore, correlation of estimated industry wage rates across the two models produces correlations of employment multipliers.

A comparison of the differences in Type I multipliers with the differences in Type II multipliers further reveals the significance of additional key assumptions of the models. The differences in Type II multipliers are proportionately larger than the Type I multiplier differences for both Nye and Lincoln counties. This occurs because REMI adjusts labor income for place of residence and IMPLAN does not. Using the BEA Local Area Personal Income series, REMI estimates the net of income earned by residents working outside the county relative to that earned by nonresidents working in the county, which equals 47.8 percent and 30.2 percent of total labor and proprietors' income, respectively, for Nye and Lincoln counties. Contrarily, IMPLAN estimates consumption using population estimates; population is assumed to completely respond to place-of-work employment. As a result, REMI predicts substantial leakage of labor income in the rural counties and hence less induced consumption than IMPLAN.

Comparisons of REMI's Type III multipliers with both REMI's and IMPLAN's Type II multipliers show the significance of the remaining endogenous components of the REMI model. The Clark County REMI Type III multipliers are larger than the REMI and IMPLAN Type II multipliers, with the differences significant for the employment multipliers. This occurs because the positive impacts of induced expenditures (both investment and government) and greater self-sufficiency from growth dominate the negative competitive effects on exports and import-competing production from increased wage rates.[7]

In contrast to Clark County, the REMI Type III multipliers for the rural counties are not generally larger than the REMI or IMPLAN Type II multipliers. Indeed, the REMI Type III multipliers (employment and output) are generally smaller than the REMI Type II multipliers in Nye County. The IMPLAN Type II multipliers also are larger than the REMI Type III multipliers. This finding reflects Nye County's high propensity to import. That is, the induced effects of investment and government expenditures and effects of increased gross regional

product on the RPC's are less than the loss of exports and the increase in imports. On the other hand, the average of the Lincoln County REMI Type III multipliers is larger than the corresponding average of the Type II multipliers for employment, but it is smaller for output. Thus, the offsetting effects of induced expenditures and supply-side constraints are more equal in Lincoln County than in Nye County.

Given the differences in multipliers and identified underlying assumptions, their underlying reasonableness can be assessed. The IMPLAN RPC's equal to one in the service sectors in all three counties are unrealistic. To be sure, most of these sectors are export oriented, and some demand for these sectors is fulfilled outside the respective counties.

Survey data is available for the rural counties on the proportion of sales by each sector to destinations within the county.[8] Accordingly, the percent of sales to destinations within the county (PS) multiplied by the ratio of supply to demand equals the regional purchase coefficient.[9] This approach is used by REMI to estimate RPC's for nonmanufacturing industries using subjectively estimated PS values. Using both REMI and IMPLAN supply/demand ratios, estimates of RPC's based on the survey PS's are calculated and reported in Table 4.

Using the PS values obtained from the Nye County survey produces RPC's for Nye County that are not significantly different between the two models and are positively, but insignificantly, correlated. The average of the IMPLAN RPC's decreases from 0.71 to 0.54, and the average of the REMI RPC's increases from 0.27 to 0.52. This suggests, all else being equal, overestimates of multipliers by IMPLAN and underestimates of multipliers by REMI.[10]

The survey-based RPC's for Lincoln County (Table 5) are not statistically different between REMI and IMPLAN; furthermore, they are significantly correlated. The average IMPLAN RPC decreases from 0.89 to 0.35, and the average REMI RPC decreases from 0.32 to 0.22.[11] The primary reason for the result is that IMPLAN reported significant employment and self-sufficiency in sectors that according to the survey have little or no employment and corresponding PS values equal to zero. Therefore, all else being equal, IMPLAN significantly overestimates multipliers in Lincoln County. Using primary data, Radtke et al. (1985) and Taylor and Fletcher (1992) also find that IMPLAN overestimates RPC's in certain service sectors.

The estimated leakages of labor income by the REMI model for the rural counties occur because of the existence of the Nevada Test Site (NTS). A previous study has reported that 31 percent of the people employed by the Department of Energy and its contractors reside in Clark County (Desert Research Institute 1991, 5-50). They comprise about one-half of total employment in Nye County. Of the remaining employees in Nye County, 22 percent live outside the

county. Given that wage rates at NTS are above the average wage rate for southern Nevada, the labor income losses to the rural counties reported by the REMI model are generally consistent with the employee residency pattern.

Table 6 contains summary statistics of comparisons of employment and output-to-employment ratios for the three counties.[12] Employment and output-to-employment ratios reported by the two models are correlated for Clark County. The employment numbers are significantly different, with those reported by REMI being larger. Examination of Nevada State Employment Security data supports the REMI estimates, which is expected since REMI uses the ES-202 data and IMPLAN does not.

TABLE 6
Statistical Comparisons of Data

	Employment and Output/Employment					
	Clark		Nye		Lincoln	
Statistics	Emp.	Output/Emp.	Emp.	Output/Emp.	Emp.	Output/Emp.
Correlation	1.00*	0.94*	0.93*	0.89*	0.30	0.50
Spearman's Rank	0.85*	0.80*	0.24	0.65*	-0.31	0.26
Matched t-test Sig.	0.09	0.38	0.62	0.15	0.94	0.85
Wilcoxon Test Sig.	0.04	0.26	0.98	0.20	0.53	0.66
Sign Test Sig.	0.18	0.51	1.00	0.58	1.00	0.55

* Denotes significant at or below the 0.01 level.
** Denotes significant at or below the 0.05 level.
*** Denotes significant at or below the 0.10 level.

Employment and output-to-employment ratios are generally correlated for Nye County but not for Lincoln County. The dominant sector in both counties is the "Miscellaneous Business Services" sector, which exists as part of the Nevada Test Site. The different employment numbers in Lincoln County arise from IMPLAN reporting significant employment in several sectors (e.g., "Motion Pictures"), where REMI reports little or no employment. The survey data for Lincoln County supports the REMI estimates.[13]

IV. SUMMARY AND CONCLUSION

In most of the comparisons, the Type I and II multipliers of the REMI and IMPLAN models for southern Nevada differ significantly. Comparable IMPLAN

multipliers generally are larger than the REMI multipliers.[14] In addition, the Type I and II output multipliers of the two models are not significantly correlated. Therefore, in addition to the models disagreeing on the typical multiplier response, they also disagree on which industries have the largest and smallest multipliers. However, the employment multipliers generally are significantly correlated because of the correlation of industry wage rates. The Type III multipliers of the REMI model are larger for Clark County but generally smaller for the rural counties than IMPLAN's Type II (and REMI's Type II) multipliers.

Differences in estimated regional purchase coefficients (RPC's) cause the differences in Type I multipliers and some of the differences in Type II multipliers. Moreover, the pattern of the RPC's causes the output multipliers to be uncorrelated. The proportionately larger differences between Type II multipliers in the two rural counties occur because of labor income leakages that REMI estimates and IMPLAN does not. The larger Type III REMI multipliers in Clark County occur because induced investment and government expenditures dominate growth, inhibiting supply-side effects. However, the supply-side effects dominate the induced effects in the rural counties because of their high propensities to import.

These results have general applicability. First, models such as IMPLAN, which estimate self-sufficiency (RPC's equal to one) in service sectors, overestimate multipliers in tourist economies, particularly small rural economies. However, approaches that incorporate survey information for tourist sectors with the IMPLAN model can overcome this weakness (Harris and Fletcher 1992; Fletcher and Taylor, forthcoming). Second, IMPLAN is less applicable for economies where a significant amount of people commute into the area for work. In this study, significant commuting occurred in the rural counties because of the Nevada Test Site. Finally, because of the high propensity to import in Nye and Lincoln counties, calculation of additional induced effects (as REMI does) is not critical for similar small rural economies. Moreover, the estimated negative supply-side effects by REMI are probably inaccurate and should be suppressed during use in small rural economies.

The comparisons in this study also sought to establish general criteria for evaluating regional economic impact models. Four criterion seem applicable. First, more than one industry should be used in model comparisons. Models may produce similar multipliers for one industry but dissimilar multipliers for most industries. Second, models should also be evaluated according to whether they are accurate in estimating the relative importance of the industries in the region. Third, the models need to be standardized for comparison, particularly when evaluating complex models such as REMI. This allows for more definite conclusions to be drawn about the systematic differences between the models and

relative accuracy. Fourth, comparisons should be performed for different size and type of economies, for example, large urban and small rural regions.

ENDNOTES

1. Since the REMI model is not strictly an input-output model, it was not included in the Brucker et al. (1990) study.

2. IMPLAN's Type III multiplier is conceptually similar to Miernyck's Type III multiplier.

3. Alhough the government sectors are significant employers in the counties, problems with comparison preclude their inclusion in the analysis. REMI contains three government sectors: state and local government, federal civilian government, and federal military government. However, they are not included in the input-output component, and government expenditures are not linked to government employment in the model. The IMPLAN model contains three detailed government sectors plus six federal government and state and local government enterprises.

4. The multipliers from the REMI model are averages of the multipliers for 11 year simulations (1990 – 2000).

5. Matched t-tests require the assumption of normality. The Wilcoxon test relaxes the normality assumption to that of symmetry. The Sign test relaxes the symmetry assumption, requiring only that the data at least be ordinal.

6. Statistical tests of the parametric correlation coefficients assume bivariate normality. Tests of Spearman's Rank correlation coefficients relax the normality assumption.

7. Crihfield and Campbell used an earlier version of REMI where population was less responsive to changes in employment demand. Thus, all else being equal, they would have found smaller REMI Type III multipliers.

8. The surveys were conducted by the Center for Business and Economic Research at the University of Las Vegas, Nevada.

9. RPC = Sales for Local Demand/Total Local Demand = PS * Supply/Demand.

10. For both REMI and IMPLAN, the survey-based RPC's are not significantly different from or correlated with their corresponding RPC's from the models.

11. The survey-based IMPLAN RPC's are statistically different and significantly and negatively correlated with the IMPLAN model RPC's. Survey-based REMI RPC's are not statistically different from the RPC's of the REMI model provided and are significantly and positively correlated.

12. Tables of the employment and output/employment ratios are available from the authors. The year used for the comparison is 1985.

13. The difference is not significant because in "Miscellaneous Business Services," REMI reports employment of 1,098 and IMPLAN reports 230, which offsets the greater reported employment levels in sectors by IMPLAN, producing a mean difference near zero.

14. IMPLAN 1985 reports Type III multipliers after one iteration of induced effects. Fully iterated multipliers that would be larger than the reported multipliers could have been obtained by doing individual industry simulation. These fully iterated multipliers would be even larger than the corresponding Type II REMI multipliers providing stronger support for the conclusions drawn in this paper. The current version of IMPLAN for 1990 reports fully iterated Type III multipliers, eliminating the anomaly of two sets of Type III multipliers from the same model in the 1985 version.

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