AN EVALUATION OF NON-SURVEY ESTIMATION TECHNIQUES FOR REGIONAL INPUT-OUTPUT MODELS

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Introduction

The need for an acceptable non-survey method of estimating regional input-output (I-O) models is well known. Many methods have been proposed and evaluated. Evaluations of methods have been presented by Czamanski and Malizia (1969), Shaffer and Chu (1969), Shaffer (1969), Morrison and Smith (1974), McMenamin and Haring (1974), and more recently, Cartwright, et al. (1981) and Stevens, et al. (1981). All have involved the comparison of non-survey coefficients to survey coefficients. The earlier non-survey tables were estimated from highly aggregated national tables.

This paper compares the coefficients in a survey-based input-output model to coefficients determined by regionalizing the 1972 United States input-output table at its most disaggregated level (496 sectors). The use of such disaggregated data has been proposed by most evaluators of non-survey methods to reduce the burden of the assumption that product mix does not vary between the nation and the region.¹

The objective of this study is twofold: to evaluate the relative merits of several modifications to non-survey methods and to explore the benefits of using a more disaggregated national table. The paper is organized in four parts: 1) a description of the non-survey methodologies to be evaluated, 2) a comparison of I-O tables and multipliers estimated by the non-survey methods to the survey I-O tables and multipliers, 3) a comparison of multipliers produced from disaggregated and aggregated national tables, and finally, 4) conclusions regarding the value of various non-survey methods and benefits of using a disaggregated national table.

The focus of the study is to determine which of four non-survey methods of estimating a regional I-O table provides the most accurate

representation of the structure existing in a region. The region of analysis is Sussex County, Delaware, a rural county in the southern part of the state. An I-O table originally consisting of 42 sectors was estimated for this region using survey data collected for the year 1972 (Brucker and Cole, 1979). Acknowledging Jensen's (1978) warnings against such an assumption, for purposes of this paper, the survey table is assumed to accurately depict the Sussex County economy. The coefficients obtained by several non-survey methods will be compared to the survey coefficients. Variables to be compared include coefficients from the direct requirements tables, output multipliers, income multipliers and imports.

Non-Survey Methods of Estimating I-O Models

Many non-survey methodologies have proliferated in the past two decades (Stone, 1970, Lecomber, 1971 and McMenamin and Haring, 1974). Some are short-cut methods to determine multipliers only like those designed by Drake (1976) and Burford-Katz (1981). Some were incorporated in extensive modeling systems such as RIMS II by Cartwright et al (1981) and the Stevens model for transportation impact analysis (1981). Many include modifications of older methods such as location quotient and supply-demand pool. Some of the newer methods have already been extensively evaluated in other studies (Burford and Katz, 1981, Cartwright, Bumiller and Gustily, 1981, Drake, 1976, Malizia and Bond, 1974 and McMenamin and Haring, 1974).

Therefore, in this section, *four non-survey methods of estimating regional input-output models are chosen and described. These are: location quotients, based on output and employment, supply-demand pool, and a method of estimating only multipliers proposed by Burford and Katz (1981).*

All of the methods except Burford-Katz will be used to estimate a full Input-Output table both open and closed with respect to house-

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holds. The Leontief-inverse method will be used to determine multipliers.

Location Quotients

The most frequently used non-survey method has been the location quotient method, where a location quotient is defined as:

$$LQ_i = \frac{x_i/x}{X_i/X}$$

The location quotient for an industry i in a region is the ratio of the regional output of industry i (x_i) to total regional output (x) divided by the ratio of national output of industry i (X_i) to total national output (X). Direct requirements from the national I-O table (a_{ij} 's) can be regionalized by multiplying the direct requirement a_{ij} of a given industry, j , by the location quotient (LQ_i) for the supplying industry, i .

Because users of the location quotient technique do not always have total output figures for each industrial sector, employment figures are often used to estimate location quotients. To evaluate the practice of using location quotients based on employment rather than total output, both were calculated for the sectors in Sussex County. These location quotients will be referred to as LQP and LQE for production-based and employment-based location quotients, respectively.

Supply Demand Pool Method

Another non-survey estimation method used in this paper, referred to as POOL, follows closely the technique used by Boisvert and Bills (1976). The technique is a modified supply-demand pool technique where the 496 sector national direct requirements table is collapsed to 29 sectors comparable to the survey using weights based on county employment in each of 496 sectors.² County employment data for four-digit SIC industries was available from the Delaware Department of Labor.³

The weighting procedure involves two steps. The first step is to aggregate the columns. This step weights each disaggregated coefficient (a_{kp}) of the national table (A_{kp}) according to the economic importance of the disaggregated sector in the region. The weight is the ratio of the regional employment in the disaggregated sector (p) to the total regional employment in the newly aggregated sector (j), determined by summing disaggregated sector employment

according to the specific sample definition. The weight is:

$$\frac{E_p}{\sum_{p=1} E_p}$$

where E_p is regional employment in industry p and the disaggregated sectors 1 through i make up the aggregated sector j . This procedure produces coefficients for the aggregated sectors (a_{kj} 's) that reflect the region's product mix. Technically, this is accomplished by:

$$a_{kj} = \sum_{p=1} a_{kp} \left(\frac{E_p}{\sum_{p=1} E_p} \right)$$

where:

- k = rows in national table, 1 . . . n .
- p = columns in the national table, 1 . . . n .
- j = columns in regional table, 1 . . . m , $m < n$.
- i = rows in regional table, 1 . . . m .

In the second step, the rows are aggregated to correspond to the new sectors. This produces a matrix of regional technical coefficients (a_{ij} 's). In this step, coefficients for any sector with no employment in the region are not added into the new regional production coefficients, but rather are defined as imports (non-competing). This reduces many of the problems of estimating imports.

To account for competing imports, (those for which there is some production in the region), the supply-demand pool procedure is used to adjust the a_{ij} 's. Each production coefficient is divided into a regional purchase component and an import component.

Regional transactions are estimated by multiplying regional gross industry output totals by the regional direct requirement table. Then, final demand is estimated and the region's share of national final demand.⁴ At this point, dollar purchases have been estimated for each cell in the table. Summing the elements in each row (i) gives total estimated regional demand (r_i) for sector i . Having modified the procedure used by Boisvert and Bills,

$$r_i = \sum_{j=1}^m a_{ij} x_j + \sum_{f=1}^F C_{if}$$

$$\frac{y}{\bar{Y}}$$

The difference between total estimated demand for a sector's output (r_i) and the total supply (x_i) of that sector's output can be defined

as the sector balance (b_i) where $b_i = x_i - r_i$. If b_i is greater than 0, then the balance is allocated to exports. If, however, b_i is less than 0 then the regional transactions and thus regional direct requirements for that sector's output will be adjusted downward. This procedure reflects the assumptions that all local demand is met first from local supply and that any importing is done proportionately on the basis of the relative purchases from the sector to total demand from the sector. The adjusted coefficients (a_{ij}^*) are

$$a_{ij}^* = a_{ij} x_i k / r_i$$

and competing imports for each unit of output of sector j (M_j) are

$$M_j = \sum_{i=1}^m (a_{ij} - a_{ij}^*)$$

This final adjustment produces regional transactions and direct requirements tables that reflect regional production.

Burford-Katz

If there is no need for a complete regional I-O table, Burford and Katz (1981), have provided a straightforward method for estimating multipliers (μ) only. This method has been included in the evaluation because of its appealing ease of calculations; however, it should be kept in mind that although the B-K method requires only that the fraction of an industry's purchases made in the region be known, this data is usually not available.⁵ The fraction of total output, known as total intermediate input, is called w_j . The Burford-Katz method provides estimates of the multiplier for a sector, μ_j , based on the intermediate input of sector j , w_j , relative to the mean intermediate purchase of all sectors, $\bar{w}$. Their equation is:

$$\mu_j = 1 + w_j / (1 - \bar{w})$$

This equation reflects the fact that sector multipliers will be above average for sectors having greater than average intermediate inputs. This equation was used to estimate the multipliers for Sussex County.

Comparison of I-O Coefficients

To evaluate the accuracy of the estimates made by the LQE, LQP, and POOL non-survey methods, the coefficients and multipliers are compared to the coefficients and multipliers of the survey-based table.

Measures of Closeness

Morrison and Smith (1974) provide an excellent discussion of various statistics which could

be used to evaluate how close non-survey coefficients or multipliers are to the survey coefficients and multipliers. Some alternatives include chi-square, simple regression coefficients, correlation coefficients, simple error or difference, mean absolute difference, and mean proportional difference. Of these, four are used in this study: correlation, regression, chi-square and mean proportional difference.

The advantage of chi-square, regression and correlation is that each provides a test for statistical significance. However, statisticians indicate that the limits on the values of the I-O coefficients make the accuracy of such tests of statistical significance doubtful because the initial assumptions of randomness are not met. The primary method of comparison used in this study is mean proportional difference. So that the results of this study might be compared to earlier evaluations which used chi-square, correlation and regression measures, they are also included in the results.

Mean Proportional Differences

To compare the closeness of the three non-survey tables to the survey table for several variables, it would be most helpful to look at one measure of closeness for several variables. The measure chosen for this comparison is the mean proportional difference (also called mean absolute percentage error, MAPE).

It is the most often used and clearly understood measure. It is defined as:

$$\delta = \frac{\sum_{i=1}^m \frac{|(a_{ij} - a_{ij}^*)|}{a_{ij}}}{m}$$

where:

a_{ij} are survey values and

a_{ij}^* are non-survey values.

The sum of absolute differences provides a measure of distance of two columns of tables. If each difference is calculated as a proportion, over-emphasis on large coefficients is avoided. When divided by the number of coefficients or multipliers, the mean proportional difference reflects the average proportional (or percentage, if multiplied by 100) difference of the non-survey value from the survey value.

Overall Comparison

Table 1 shows the mean proportional difference of LQE, LEP and POOL generated tables.

TABLE 1
Mean Proportional Differences.

Variable	LQE	LQP	POOL
All production coefficients	6.26	3.30	3.32
Column sums (percent regional purchases)	2.24	2.10	1.94
All production coefficients with households	6.31	3.34	3.35
Type I Output Multipliers	.1691	.1517	.1222
Type II Output Multipliers	.4674	.2172	.1701
Income Multipliers	.3950	.2220	.1819
Imports ^a	.8987	.7886	.9129
Imports (without 3 problem sectors)	.4224	.4035	.3778

^a Appendix A, Table 3.

As can be seen, the POOL method of estimating the Sussex County I-O table gives coefficients and multipliers which are on average closer to the survey table in every case, except when comparing the two entire direct requirements tables (all production coefficients). In this case, the POOL method and the LQP method produce equally close tables.

For Type I output multipliers, the POOL method estimated multipliers with a mean proportional difference (δ) of .12 while the LQE and LQP were .16 and .15 respectively. For Type II output multipliers, the range was even greater with the POOL again having the lowest mean proportional difference of .17 while LQE have .48 and .22, respectively. For the income multipliers the mean proportional differences were again lowest for the POOL and highest for LQE. It is valid to point out that our POOL technique's estimates of type I and II output and income multipliers (which are on the average, 12, 17, and 18 percent different, respectively, from the survey based table) may not be accurate enough for many purposes. It is still a higher degree of closeness than that associated with the LQE and LQP methods.

It is interesting to note that there is a fairly substantial difference between the mean proportional differences associated with using location quotients based on employment and those based on production. In every case, the coefficients and multipliers derived from the production-based location quotients are closer to the survey values than those based on employment figures. The income multipliers estimated from the LQE method are seen to be more than 39 percent different from the survey-

based table, while those estimated from the LQP method are about 22 percent different. With Type II output multipliers, the gap between the LQE and LQP methods is even more striking. In this case, the LQE estimated multipliers are almost 47 percent larger than the survey-based ones, while those estimated from the LQP method are only 22 percent higher.

Multipliers

A sector-by-sector comparison of estimated multipliers can be instructive. The Type I multipliers estimated by the survey and all four non-survey methods, as well as the proportional differences, are presented in Table 2.

The mean proportional differences over all sectors ranged from .0096 to .1691 for the various non-survey methods. The B-K method yielded multipliers with the smallest proportional difference for almost every industry, most being less than 1 percent different than the survey and the largest difference of a B-K multiplier being 3 percent in the livestock sector. Obviously, the mean proportional difference over all industrial multipliers is by far the lowest for B-K, 0.96 percent. This is in keeping with Burford and Katz's own observations that the percent error will be smaller as $\bar{w}$ is smaller. Since $\bar{w}$ of 0.17 is very low, the closeness of the multiplier estimates to those from the survey is as expected. However, since many non-survey models may not have the data to use the B-K method, it may be instructive to compare the relative merits of the other methods.

The POOL technique multipliers had proportional differences ranging from .003 to .4408, but there were only 5 sectors where the difference was greater than 20 percent and there were 15 sectors where the difference was less than 10 percent. The LQP technique yielded similar distribution of proportional differences. The range of proportional differences for the LQP was from .7411 to .0056, where the percentage difference in 7 sectors was greater than 20 percent and in 15 sectors less than 10 percent. The LQE multipliers had proportional differences ranging from .8129 to .0017, with 9 sectors' multipliers over 20 percent different from the survey multipliers and 14 sectors less than 10 percent.

It is not encouraging to note that for all three non-survey methods the largest two discrepancies from the survey occur in the largest indus-

TABLE 2
Comparison of Output Multipliers^a Estimated by Non-Survey Methods to Survey-Based Multipliers.

Sector	Multipliers					Proportional Differences			
	Survey	LQE	LQP	Pool	B-K	LQE	LQP	Pool	B-K
1 F.Crops	1.549	1.322	1.207	1.205	0.504	-.1466	-.2208	-.2221	-.0290*
2 Frt. Veg.	1.397	1.285	1.212	1.161	0.380	-.0802	-.1324	-.1689	-.0124*
3 Livestock	1.487	1.745	1.663	1.745	0.442	.1735	.1184	.1735	-.0305*
4 Broilers	1.266	2.113	2.014	1.356	0.230	.6690	.5908	.0711	-.0287*
5 Vet.	1.068	1.259	1.197	1.201	0.068	.1788	.1208	.1245	.0005*
6 Ag Supply	1.132	1.545	1.46	1.303	0.135	.3648	.2898	.1511	.0031*
7 P. Proc.	1.352	2.451	2.354	1.948	0.339	.8129	.7411	.4408	-.0095*
8 V. Proc.	1.208	1.418	1.328	1.345	0.190	.1738	.0993	.1134	-.0147*
9 Fishsim	1.114	1.191	1.143	1.132	0.122	.0691	.0260	.0162	.0070*
10 Cons. New	1.219	1.215	1.173	1.178	0.213	-.0033*	-.0377	-.0336	-.0051
11 Cons. Mnt.	1.171	1.239	1.206	1.214	0.138	.0581	.0299	.0367	-.0278*
12 Apparel	1.012	1.317	1.273	1.28	0.013	.3014	.2579	.2648	.0006*
13 Oth. Man.	1.018	1.415	1.359	1.372	0.019	.3900	.3350	.3477	.0014*
14 Trans	1.143	1.223	1.167	1.207	0.150	.0700	.0210	.0560	.0064*
15 Commun.	1.051	1.3	1.289	1.275	0.053	.2369	.2265	.2131	.0023*
16 Utility	1.145	1.41	1.295	1.392	0.152	.2314	.1310	.2157	.0060*
17 Whlsl Td.	1.256	1.192	1.15	1.161	0.268	-.0510	-.0844	-.0756	.0097*
18 Restaurant	1.258	1.341	1.251	1.246	0.261	.0660	-.0056	-.0095	.0026*
19 Ret. Trade	1.199	1.189	1.118	1.131	0.206	-.0083	-.0676	-.0567	.0058*
20 Finance	1.196	1.231	1.187	1.201	0.202	.0293	-.0075	.0042*	.0050
21 Insurance	1.096	1.33	1.289	1.23	0.098	.2135	.1761	.1233	.0019*
22 Real Estate	1.352	1.217	1.142	1.145	0.377	-.0999	-.1553	-.1531	.0182*
23 Lodging	1.353	1.392	1.223	1.243	0.366	.0288	-.0961	-.0813	.0093*
24 Pers. Ser.	1.242	1.239	1.146	1.152	0.253	-.0024*	-.0773	-.0725	.0091
25 Repair	1.159	1.161	1.103	1.107	0.172	.0017*	-.0483	-.0449	.0114
26 Amusement	1.111	1.37	1.312	1.293	0.118	.2331	.1809	.1638	.0067*
27 Profess.	1.087	1.194	1.158	1.162	0.091	.0984	.065	.0690	.0042*
28 Other Ser.	1.262	1.278	1.206	1.212	0.259	.0127	-.0444	.0396	-.0023*
29 Education	1.167	1.282	1.152	1.163	0.174	.0985	-.0129	.0034	.0062*
Mean ^b	1.209	1.375	1.303	1.268	1.2067	.1691	.1517	.1223	.0096

* Indicates lowest proportional difference for each sector.

^a Without endogenous households.

^b Mean of absolute values.

try in Sussex County—broiler production and processing.⁶ The smaller discrepancies seem to occur in the service industries, trade, finance and construction.⁷ The relative errors seem to be consistent whichever method you use, suggesting that some sectors may need to be surveyed whatever non-survey method is chosen. This consistency is encouraging in that a semi-survey of only dominant regional industries should greatly improve any non-survey results.

Imports

Table 1 contains a comparison of imports using the mean proportional difference. This clearly indicates that the estimate of regional purchases is still an error-producing step in all of the non-survey procedures. It is only slightly more heartening that if the overestimates and underestimates of the various sectors (which can be seen in Table 3, Appendix A) are allowed

to net each other out, the estimates of total imports relative to the survey total imports are greatly improved. Specifically, the LQE estimate of \$246,958,180 is 32 percent less than the survey total imports of \$363,860,100, the LQP estimate of \$212,493,870 is 41.6 percent less than the survey, and the POOL estimate of \$393,291,680 is only 8 percent greater than the survey.

It would be instructive to look at where the divergence from the survey takes place. The major errors in the estimating of imports are in the same three sectors for all three non-survey methods. The magnitude of these errors ranges from 200 to 700 percent and, therefore, they are strongly impacting the mean proportional difference. The three sectors are 6, 9, and 20, which are Agricultural Supply, Fishing, Forestry and Mining, and Finance, respectively. In the two first sectors, Agricultural Supply and

TABLE 3
Regression Analysis Comparing Non-Survey to Survey Tables.

Variable	LQE	LQP	POOL
All Production Coefficients (N = 841)			
Mean (Survey = .0059)	.0092	.0076	.0071
Regression constant (α_i)	.0033	.0037	.0034
Regression coefficient (β_j)	.2872	.2959	.3614
Coefficient of determination (R^2)	.2997	.2945	.3352
All Production Coefficients With Households (N = 900)			
Mean (Survey = .0193)	.0250	.0233	.0183
Regression constant (α_i)	.0003	.0014	.0002
Regression coefficient (β_j)	.7599	.7645	1.0372*
Coefficient of determination (R^2)	.8189	.8246	.8008
All Interdependence Coefficients (N = 841)			
Mean (Survey = .0417)	.0474	.0449	.0438
Regression constant (α_i)	-.0028	-.0006	.0002
Regression coefficient (β_j)	.9388	.9426	.9469
Coefficient of determination (R^2)	.9693	.9714	.9818
All Interdependence Coefficients with Households (N = 900)			
Mean (Survey = .0796)	.1128	.0890	.0713
Regression constant (α_i)	-.0081	-.0015	-.0056
Regression coefficient (β_j)	.7773	.9108	1.0381*
Coefficient of determination (R^2)	.3985	.9429	.9288

The null hypothesis that β_j is equal to zero was rejected at the .001 level for all of the above equations.

*The null hypothesis that β_j is equal to one was not rejected at the .001 level.

Fishing, Forestry and Mining, there are obvious differences in product mix not captured by the weighting procedure. In the Finance sector, the sampling in the survey could be questioned and therefore, the accuracy of the sample could be at fault. If the three problem sectors are eliminated, then the mean proportional differences would be: .4224, .4035 and .3778 for the LQE, LQP and POOL methods, respectively.

Regression and Correlation Analysis

In order to test the general relationship between the survey and non-survey values, regression and correlation analysis were used. The correlation analysis related survey values to non-survey values. The regression analysis estimated the following relationship:

$$a_{ij} = \alpha_j + \beta_j a_{ij}^*$$

where:

a_{ij} is a survey coefficient, the dependent variable.

a_{ij}^* is a non-survey coefficient, independent variable.

If the non-survey estimates are close to the sur-

vey, then the α_j term will be expected to tend toward zero and the β_j term toward 1.

In Table 3, the results of the regression analysis are given for all production coefficients (from the direct requirements tables), where all 841 cells of the non-survey direct requirements table were regressed on those of the survey table. Results for a closed model, including households and for the interdependence tables as a whole, are also reported in Table 3.

In general, the non-survey values are related to the corresponding survey value. The significance of the regression coefficients (β_j) indicate a significant overall relationship between the non-survey and survey values in all four tables for all three methods. The POOL method seems to most closely estimate the survey tables as indicated by regression coefficients close to 1. In those cases where the regression coefficient is less than one it is indicative that the non-survey tables have over-estimated the coefficients. As can be seen by the relative mean values for the coefficients, the LQE consistently gives the greatest over-estimation.

Non-survey coefficients were correlated with survey coefficients by column for both the direct requirements table and the inverted, interde-

pendence table. It is interesting to note the difference in results. For direct requirements, all three methods consistently estimated some sectors well (correlation coefficients significant at the .05 and .001 level). However, there are many sectors for which no method provides a column of production coefficients highly correlated with the survey's column. This could, in part, be due to the many zero elements in the survey input structure.

The correlation of the interdependence coefficients produced correlation coefficients that were significant at the .001 level for every sector. In all but one sector, the correlation coefficients were .9900 or greater. The one exception was the poultry processing sector where the coefficients were .90, .91, and .95 for the LQE, LQP, and POOL methods, respectively.

Chi-square Analysis

Because of serious objections to the use of the chi-square test discussed in detail by Morrison and Smith (1974), it will be used in this paper only as a relative measure and for reference to Shaeffer and Chu's (1969) results.

The Chi-square statistic is:

$$X_j^2 = \sum_{i=1}^m \frac{(a_{ij} - a_{ij}^*)^2}{a_{ij}}$$

where a_{ij} 's are used in percentage form so that standard table criterion values will apply.

Table 4 in Appendix A shows the sectors for which there was no reason to reject the null hypothesis that the non-survey estimates of the production coefficients were the same as the survey-based coefficients. Using the chi-square test as a relative measure of goodness of fit, the table also indicates which non-survey method had the lowest chi-square value in 18 of the 29 sectors. Also, in most cases when one method provided an acceptable chi-square value so did the others, but in the case of the broiler indus-

try—Sussex County's largest industry, sectors 4 and 7—only the POOL method yielded chi-square results below the criterion value.

Using Aggregated Versus Disaggregated National Tables

One of the objectives of this study is to compare the accuracy of the location quotient method of estimating I-O coefficients when an aggregated and a disaggregated national table are regionalized.

The analysis up to this point has been based on collapsing a 496 sector national I-O table to a 29 sector table. A second set of location quotient estimates of Sussex County I-O tables were made using the 1972 national I-O table with 77 sectors (Appendix A, Table 2). For these estimates, the 77 sector table is aggregated by row and column. Due to the level of aggregation and survey sector definition, this results in 21 sectors comparable to the survey. The survey transactions table is also aggregated into the same 21 sectors. Employment and production-based location quotients are then calculated for the 21 sectors and multipliers estimated. Survey multipliers for the corresponding sectors are also calculated. These location quotient-estimated tables of coefficients and multipliers can be compared to those from the survey. Table 4 facilitates such a comparison for the output multipliers only. Because we are also interested in evaluating the Burford-Katz method for estimating multipliers, the closeness of those multipliers to the survey multipliers is also evaluated.

Table 4 summarizes the comparison of survey and non-survey based output multipliers for all techniques, including location quotient methods where both an aggregated and disaggregated national table were used. The estimating techniques for the aggregated table will be

TABLE 4
Type I Output Multipliers

Measure	Survey 29 Sectors	LQE	LQP	POOL	B-K	Survey 21 Sectors	LQEAG	LQPAG
Mean of Multipliers	1.209	1.375	1.303	1.268	1.207	1.182	1.509	1.503
Mean Proportional Difference		0.1691	0.1517	0.1223	0.0096		0.2905	0.2926
Sum of Absolute Difference		5.904	5.385	4.308	0.359		6.8668	6.7366
Mean Difference		0.2036	0.1857	0.1486	0.0124		0.3270	0.3276

referred to as LQEAG and LQPAG. Overall, the results indicate that better non-survey estimates of Type I multipliers are achieved when a disaggregated table is regionalized.

It is not surprising to note the striking difference in the mean proportional differences of the LQE and LQP and that of the LQEAG and LQPAG. The mean differences for the LQE and LQP are 17 and 15 percent, respectively; while the mean proportional differences for the LQEAG and LQPAG are both 29 percent. Since input-output researchers have been proposing the use of a more disaggregated national table as a means to improve non-survey results, these mean proportional differences and the other measures of closeness in Table 4 only confirm their expectations.⁸

Observations concerning the difference in the multipliers estimated using the employment-based and production-based location quotients may be more unexpected. The differences are quite pronounced when comparing type II output multipliers and income multipliers. The difference is less acute when comparing Type I output multipliers and almost non-existent when comparing the output multipliers estimated from the aggregated national table. Hence, it may be acceptable to use the employment-based location quotient as a proxy for the production-based location quotient when using the aggregated national table or when only estimating Type I output multipliers.

On the basis of the data in Table 4, it can be seen again that the multipliers estimated using the B-K method are closer to the survey-based multipliers. As Morrison and Smith found with RAS earlier, this indicates that if data for the percent of total industry expenditures that are regional are available, then estimates of multipliers will be very accurate. The B-K method is appealing in its straightforward calculation and accuracy. However, since its data requirements are rarely fulfilled by non-survey data, it may still be necessary to use one of the other methods.

Conclusions

While the authors recognize the limitations of results based on a study on one small county and its specific economic structure, there are several conclusions that seem clear from this study. First, if one needs to estimate a full I-O table and cannot undertake a survey, the POOL method based on the most disaggregated

national table will provide estimated coefficients and multipliers closer to a survey than would location quotient methods. This is a finding not shared by earlier investigations. A possible reason for this is the different method used to estimate final demand. If only the multipliers are needed and data on regional purchases as a percent of total expenditures is available, then the Burford-Katz method would minimize expense and provide very accurate estimates of output multipliers. In fact, the results may indicate that a survey to determine that total regional purchases as a percent of total expenditure would be very cost effective.

As expected, use of a disaggregated national table does provide regional output multipliers that are closer to survey estimated multipliers. The use of employment-based location quotients as a proxy for production-based location quotients seems to be justified if one is using an aggregated national table. However, the two will not be interchangeable if one is using a disaggregated national table.

Since the estimation of imports by sector seems to be very inaccurate, confirming the work of both Burford and Katz (1981), and Stevens and Trainer (1976), it would seem wise to try more semi-survey techniques. It appears that non-survey methods are especially vulnerable in the very sectors for which they are most important—the large industries in a region. Possibly this would indicate the need for, at the very least, a survey of the percent of total expenditures made on local purchases for the largest regional industries.

FOOTNOTES

¹Schaffer and Chu (1969) mention this on p. 96 and Morrison and Smith (1974) made reference to this in the conclusions section of their book.

²This weighting method was first used by Shen in 1960. The POOL technique is similar to that in Moore and Peterson's Utah study (1955).

³Collected for Unemployment Insurance Service and therefore, probably available in all states. This is actually a proxy for output data which is not available at the four-digit SIC level.

⁴Following Isard's (1953) method for determining regional commodity balances, the determination of regional final demand from national final demand dollar figures was estimated by multiplying national final demand by the ratio of regional personal income (y) to national personal income (Y). Ratios of other relevant measures such as regional to national expenditures were used to estimate the education column and new constructions figures for the capital formation column.

⁵Both Morrison and Smith (1974) and Czamanski and Malizia (1969) evaluations have included Stone's (1970)

non-survey technique, RAS. They found its tables considerably closer to a survey-based table than LQ methods. Because it requires the same information as the B-K method, but is more difficult to perform, it is not included in this study.

Czamanski and Malizia also found that region's specialized industries are often misestimated.

This is the opposite of what Czamanski and Malizia found—that tertiary industries exhibit the largest errors.

It may be significant to note that not only do all our measures of closeness indicate the increased accuracy associated with using the disaggregated national table, but also comparisons with results of earlier studies confirm this. Although there are many problems with comparing results across different regional models, it is interesting that the mean proportional differences for output multipliers for LQE, LQP and POOL for Sussex county, all based on the 496 sector national I-O model, are all lower than the mean proportional differences in the Morrison and Smith evaluation (from .1724 to .2525, except for the mean proportional difference of the RAS estimated table, $-.0006$, from the survey based table). Using the chi-square test (with $\alpha = .05$), the hypothesis of sameness can not be rejected for a large percent of sectors in the Sussex non-survey studies (18 of 29) than in Schaffer and Chu's results (7 of 23).

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APPENDIX A TABLE 1

Sector Composition Used in the Comparison of the Survey Table to Tables Estimated from Disaggregated U.S. I-O Tables (496 Sectors).

Sectors	Sussex County Survey Sectors ^a	U.S. I-O Sectors (1-496) ^b	SIC Codes (included)
1 Field Crops	1	5-9, 13-17	011-0139
2 Frt. Veg.	2	10-12	016-0189
3 Livestock	3	1, 3 & 4	021-0241, 027-0291
4 Broilers	4	2	025-0259
5 Vet.	6	477	0741, 0742
6 Ag Supply	8	19, 102, 103, 457	071-0729, 075-0783
7 P. Proc.	9	83-91	201-2026
8 V. Proc.	10	92-101, 104-126	203-2099
9 Fishfsim	11	18, 20-26	08-1499
10 Cons. New	12	27-59	15, 16, 17
11 Cons. Mnt.	13	60-76	15, 16, 17
12 Apparel	14	145-151	23
13 Oth. Man.	15	127-144, 152-443	21, 22, 24-39
14 Trans.	16	444-450	40, 41, 42, 44-47
15 Commun.	17	451-452	48
16 Utility	18	453-455	49
17 Whsl. Td.	19	456	50, 51
18 Restaur.	28	471	5812, 5813
19 Ret. Trade	7, 20-27, 29-31	457	52-59
20 Finance	32	458-460, 486	60, 61, 62
21 Insurance	33	461, 462	63, 64
22 Real Estate	34	463, 464	65, 66, 67
23 Lodging	35, 36	465	701-704
24 Pers. Ser.	37	466, 467	72
25 Repair	38	472	76, 76
26 Amusement	39	473, 474	78, 79
27 Prof. Ser.	41	470	81, 89
28 Other Ser.	42	468, 469, 475-483	73, 80, 83, 84, 86
29 Education	40	478	82
Households	Households	Consumption (column) ^c	—
Imports	Imports	Sector No. 491 and estimates of competing and noncompeting	—

^aBrucker and Cole, op. cit. p. 18.^b"Detailed Input-Output Structure of the U.S. Economy: 1972," U.S. Department of Commerce, Bureau of Economic Analysis, 1979.^cValue added row elements were modified on basis of ratio of wages, salary and proprietary payment components of total value added from *Scientific American's* Wall Chart, "Input-Output Structure of the United States Economy," 1980.

APPENDIX A TABLE 2

Sector Composition Used in the Comparison of the Survey
Table to Tables Estimated from Aggregated U.S. I-O
Tables (77 Sectors).

Sector	Sussex County Survey Sectors ^a	U.S. I-O Sectors (1-77) ^b
1 Field Crops	1, 2	2
2 Livestock	3, 4	1
3 Ag Supply	8	4
4 Food Proc.	9, 10	14
5 Fishfsim.	11	5-10
6 Cons. New	12	11
7 Cons. Mtn.	13	12
8 Apparel	14	18
9 Other Man.	15	13, 15, 16, 17, 19-64
10 Trans.	16	65
11 Commun.	17	66, 67
12 Utility	18	68
13 Trade	19, 20-27, 29-31	69
14 Restaur.	18	74
15 Finance	32, 33	70
16 Real Estate	34	71
17 Lodging	35, 36, 37	72
18 Repair	38	75
19 Amusement	39	76
20 Prof. Ser.	41	73
21 Other Ser.	42	77

^aBrucker and Cole, op. cit. p. 18.

^b"The Input-Output Structure of the U.S. Economy, 1972."
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APPENDIX A TABLE 3
Estimated Imports for Sussex County.

Sector	Total Imports (\$1,000's)				Proportional Differences		
	Survey	LQE	LQP	POOL	LQE	LQP	POOL ^a
1 F. Crops	2261.9	3299.8	2083.3	5852.1	.4589	.0790	.5006
2 Frt Veg.	1783.3	1738.8	1268.4	3728.5	.0250	.2887	.1624
3 Livestock	828.1	1791.4	1578.6	2192.0	1.1633	.9063	1.0364
4 Broilers	54417.9	11664.3	9372.7	51596.1	.7857	.8278	.1029
5 Vet.	1512.5	703.3	525.3	1527.0	.5350	.6527	.5357
6 Ag Suppl	326.2	1788.2	1534.2	2826.4	4.4819	3.7032	6.1076
7 P. Proc.	25058.3	5810.5	4504.4	7969.0	.7681	.8202	.7808
8 V. Proc.	24934.0	19418.6	16981.5	21373.3	.2212	.3189	.2478
9 Fishfsim.	53.6	226.5	196.7	391.2	3.2267	2.6691	3.3594
10 Cons. New	27452.6	28216.3	26716.0	33187.9	.0278	.0268	.0241
11 Cons. Mnt.	8690.5	5239.0	4831.5	8513.7	.3972	.4440	.4070
12 Apparel	20939.1	14896.8	13959.4	18146.3	.2886	.3333	.2940
13 Oth Man	135279.3	109193.3	96838.2	153596.1	.1928	.2842	.2089
14 Trans.	4839.4	2048.0	3028.9	6128.3	.5768	.3741	.3281
15 Commun.	1486.9	1747.5	1711.9	3189.0	.1753	.1513	.2458
16 Utility	2605.78	3546.2	2384.5	4871.7	.3609	.0849	.0166
17 Whsl. Td.	1980.9	1096.3	851.7	2472.0	.4466	.5701	.4701
18 Restaur.	9572.6	7922.8	6679.8	9878.9	.1723	.3022	.1856
19 Ret Trade	15423.9	7816.4	4241.6	19430.2	.4932	.7250	.5198
20 Finance	285	2385.5	1996.6	4778.1	7.3703	6.0057	7.1848
21 Insur.	12732	4451.2	3886.4	7708.8	.6504	.6948	.6558
22 Real Est.	1701	1511.3	557.1	4458.1	.1115	.6725	.1252
23 Lodging	771.4	1485.6	719.4	2375.1	.9259	.0674	.8652
24 Pers. Ser.	896.9	1081.9	770.5	1842.1	.2063	.1410	.1969
25 Repair	1467.6	1240.5	1116.5	1597.6	.1548	.2392	.1576
26 Amuse.	1008	788.9	649.0	1393.1	.2173	.3562	.1549
27 Profess.	1604.2	986.0	794.5	2675.2	.3853	.5047	.3904
28 Oth. Ser.	1963.9	1193.7	863.0	2428.6	.3922	.5606	.3978
29 Educ.	1983.4	3669.4	1852.4	7165.5	.8501	.0661	.8120
Sum	363860.1	246958.2	212493.9	393291.7	26.0613	22.8700	26.4742
Mean					.8987	.7886	.9129

^aNot adjusted for non-resident employees.

APPENDIX A TABLE 4
Sectors With Non-Reject Criterion Levels^a

Sector	LQE	LQP	POOL	Method With Lowest X ² for This Sector
1 F. Crops				LQP
2 Frt. Veg				LQP
3 Livestock	X	X		LQP
4 Broilers			X	POOL
5 Vet.	X	X	X	POOL
6 Ag Supply		X	X	POOL
7 P. Proc.			X	POOL
8 V. Proc.	X	X	X	LQP
9 Fishsim.	X	X	X	POOL
10 Cons. New				LQE
11 Cons. Mnt.		X	X	POOL
12 Apparel	X	X	X	LQP
13 Oth. Man.	X	X	X	LQP
14 Trans.	X	X	X	POOL
15 Commun.	X	X	X	POOL
16 Utility	X	X	X	LQP
17 Whlsl. Td.				POOL
18 Restaurant				POOL
19 Ret. Trade				POOL
20 Finance		X	X	POOL
21 Insurance	X	X	X	LQP
22 Real Estate				POOL
23 Lodging				POOL
24 Pers. Ser.			X	POOL
25 Repair	X	X	X	POOL
26 Amusement	X	X	X	POOL
27 Profess.	X	X	X	POOL
28 Other Ser.				LQE
29 Education				POOL
Significant Sectors	13	16	18	

^aCalculated using columns of direct requirements tables without households. Criterion value for .05 level of significance is 41.44.