MCRSA Presidential Symposium – 36th Annual Conference; JRAP 36(1): 84-93.

The Journal of
Regional
Analysis
& Policy

An Evaluation of Method for Constructing Commodity by Industry Flow Matrices

Walter R. Schwarm, Randall W. Jackson, and Yasuhide Okuyama
Regional Research Institute, West Virginia University - USA

Abstract. The lack of consistent, reliable data on interregional trade and interindustry transactions hampers complete analysis of regional models. This study implements and tests interindustry transaction flows in a national system of economic regions derived from an interregional accounting framework and initial information on interregional shipments. The method used to construct an interregional Commodity by Industry Flow matrix for the United States involves the construction of single-state SAMs. The interregional flows connecting states are estimated using a method based on the Commodity Flow Survey data published by the Bureau of Transportation Statistics, which adjusts the estimated interregional SAM to insure the integrity of intraregional and system-wide, national accounts. This paper presents the results of exercises testing the validity of the resulting interregional trade-flow data using, among other data sources, the CFS itself, the FAFD and S&P/DRI regional estimates. The model is tested is a US interregional framework describing flows within and among the 50 states and the District of Colombia.

1. Introduction

The importance of accurately estimating commodity imports cannot be overemphasized. With deregulation and structural change economic interactions among industries, governments, and households become more closely tied and complex. Trade within the interregional domestic context has received far less attention than its international counterpart. Recent studies have found in both the US and Japan that interregional trade within a country is growing more rapidly than intra-regional and international trade, and that regions have become tied very closely together (for example, Hewings *et al*., 1998, and Hitomi *et al*., 2000). In fact, according to the Commodity Flow Survey (CFS) of the Bureau of Transportation Statistics, US industries shipped approximately $7 trillion worth of goods in 1997 an increase of 18.8 percent (up 14.5 percent and 9.9 percent for tons and ton-miles, respectively) since 1993.

As the volume of interregional trade increases it is likely that the trading patterns also become more complex. In particular, investigating economic relationships in further detail, identifying, for example, which industries in one state have the strongest and the closest relationships with a given industry in another, can provide a better understanding of how policy changes in one region (state) create impacts other regions (states).

Given the importance of such interregional estimates the challenges to estimation are reflected in the relative dearth of examples in the literature. Notable studies include the recent Liu and Vilain(2004) who compare forecasts of interregional trade flows with CFS values for a six region model of the U.S. Canning and Zhi (2005) employ SAM methods to construct an interregional Commodity by Industry flow matrix for the United States. It presents an export distribution estimation method, and describes the steps necessary to generate the interregional trade flow portions of an ISAM, and to insure the consistency of both the individual SAM accounts and the system as a whole. Celik and Guildmann (2002) estimate a spatial interaction model of commodity flows combining origin and destination variables from the County Business Patterns

(CPB), Census of Manufactures, and BEA with a pair of geographical characteristics to produce estimated flows between O-D pairs. They find that the Box-Cox functional form chosen, combined with the selected variables, yields reasonable success in explaining flow variation.

Empirical methods and applications similar to ours for US states were first done during the 70's, initiated at the Harvard Economic Research Project and developed by Polenske (1972). In its most detailed form, it described a 51-region multiregional input-output (MRIO) model for 1963 (50 states and Washington, D.C.) with 79 sectors in each region (see Polenske 1980 for a complete description of the model and its construction). The staff at Jack Faucett Associates, Inc. assembled the 1977 version of the US MRIO model for 51 regions and 120 industries (Faucett Associates, 1983). These US MRIO models have brought many new research opportunities for the detailed analysis of economic structure and policy analysis and were employed in numerous research projects in subsequent years. Recent applications of these models include Miller and Shao (1990) comparing 1963 and 1977 models to examine the sectoral and spatial aggregations, the US Army Corps of Engineers (1994) creating their own Red River MRIO model based on the 1977 model to evaluate the Red River Water Project, and Horiba (2000) examining interregional trade in comparison to interregional migration in the US using the 1977 model.

The paper is organized as follows: After problem and data definition we present a brief summary of the methods used to generate interregional trade characteristics by commodity and the adjustments used to insure the integrity of the intra-regional and system wide accounts. This summary is followed by a discussion of some of the aspects of the validation problem and comparisons of other trade estimates with those provided by our method, finally we present discussion of the relevant differences and analysis of the validation exercise.

2. Organization and Data

The Social Accounting Matrix (SAM) framework details interactions among economic agents (industries, governments, households, etc.). The SAM framework describing the full circular flow of income, establishing separate accounts for production, consumption, and transaction with other regions, was originally pioneered by Stone (1961), and applied at the regional and interregional level by Pyatt and Round (1983), Round (1985), and Bell *et al.* (1982).

Our procedure produces a similar and current database for interindustry activities among regions but also generates a more extensive and complete database for the US state economies. Moreover, the interregional SAM described in Jackson et.al. (2006) specifies interregional relationships, more comparable to Isard's (1951) interregional input-output framework, providing more detailed information regarding economic interactions across regions than the multiregional framework Polenske's model provided.

2.1 SAMs and Data

The interregional trade estimates are constructed from IMPLAN single-region generated data partitions for a single region SAM, with imports treated separately (import ridden as opposed to import laden). The IMPLAN SAM data are reported in this format to assist GAMS users in constructing single region CGE models from IMPLAN data. Industry sectors were defined in such a way as to correspond closely with the commodity codes used by the US Bureau of Transportation Statistics. The modeled framework encompasses fifty-one regions and 54 industry and commodity sectors, along with four factors of production and 18 institutions.

The general structure of the *interregional* SAM is shown in Figure 1, which depicts a 3-region SAM, but which generalizes straightforwardly to our 51-region case. The challenge in constructing the interregional SAM lies in the estimation of values for the shaded and labeled partitions of the off-diagonal blocks in the diagram in Figure 1, and the necessary adjustments to other sectors to ensure a balanced table consistent with the accounting identities of the SAM.

2.2 Export Distributions

The US Bureau of Transportation Statistics collects data through its commodity flow survey (CFS). Although these state-to-state commodity flow estimates are published and available from the BTS, their usefulness is limited for a number of reasons. Foremost among these reasons is that for almost all listed commodities, state-to-state origin-destination tables are dominated by disclosure codes or other annotations. The most common of these codes indicates that the estimate is not published due to an unacceptably high statistical variability, and thus, little confidence in the estimate. A second problem for model construction is that the CFS data report shipment origin and destination rather than manufacturing origin. An alternative approach which has the effect of generalizing the distance-volume relationships embedded in the BTS data,

		Region 1				Region 2				Region 3				
		Ind	Com	Fac	Inst	Ind	Com	Fac	Inst	Ind	Com	Fac	Inst	ROW
R1	Industry		r011x2				r01021x8				r01031x8			r011x7
	Commodity	r012x1			r012x4	r01028x1			r01028x4	r01038x1			r01038x4	
	Factors	r013x1												
	Institutions		r014x2	r014x3	r014x4		r01024x8				r01034x8			r014x7
R2	Industry		r02011x8				r021x2				r02031x8			r021x7
	Commodity	r02018x1			r02018x4	r022x1			r022x4	r02038x1			r02038x4	
	Factors					r023x1								
	Institutions		r02014x8				r024x2	r024x3	r024x4		r02034x8			r024x7
R3	Industry		r03011x8				r03021x8				r031x2			r031x7
	Commodity	r03018x1			r03018x4	r03028x1			r03028x4	r032x1			r032x4	
	Factors									r033x1				
	Institutions		r03014x8				r03024x8				r034x2	r034x3	r034x4	r034x7
	Foreign Trade	r017x1			r017x4	r012x1			r0217x4	r037x1			r037x4	
	For Fac Imports			r015x3				r025x3				r035x3		
	Dom Fac Imports			r016x3				r026x3				r036x3		
		TIO	TCO	Total Fac. Pmts.	Total Inst. Exp.									

Row and Column Totals
Industry Row - Total Regional Industrial Output (make)
Industry Column - Total Regional Industry Input (use) (Output)
Commodity Row - Total Regional Commodity Supply (Disposition)
Commodity Column - Total Regional Commodity Supply all sources
Factor Row - Total factor receipts (payments to factors) of production
Institutions Row - Total Institutional Receipts (payments to institutions)
Factor Column - Total factor payments to institutions (and trade)
Institutions Column - Total Regional Institutions Expenditures (use)

Figure 1. General structure of the interregional social accounting matrix (SAM)

smoothing out irregularities observed in the more specific origin-destination commodity-specific shipments data, and enabling application to regions whose boundaries do not coincide with states is used in this paper.

The method operates roughly as follows (further details can be found in Jackson et. al. (2006)): We assume that the *distribution of exports* from one region to all others is fixed, while *export levels* vary with regional production. Hence, our estimating equation need only be a function of transportation costs (as measured by interregional distances) and region-specific commodity demand. For each commodity i, let the predicted value of the flow from region m to region n be computed as shown in equation 1,

$$\hat{y}_i^{mn} = \frac{\left(w_i^n\right)^{\varphi_i} \exp(-\delta_i d^{mn})}{\sum_n \left(w_i^n\right)^{\varphi_i} \exp(-\delta_i d^{mn})} y_i^{m\bullet} \qquad (1)$$

where $\left(w_i^n\right)$ is a weight reflecting region n's demand for imports of commodity i, d^{mn} is the distance separating region m from region n, and $y_i^{m\bullet} = \sum_{n \neq m} y_i^{mn}$ is total domestic commodity i exports from region m.

Where the y_i^{mn}, ideally, are actual shipments derived from observed values published in the 1997 BTS Commodity Flow Survey (CFS). δ_i and φ_i are elasticities on distance and commodity demand, respectively. Commodities with larger φ values are more sensitive to demand variations, while those with smaller values for δ are more sensitive to shipment distances.

Ideally, to estimate the values of the elasticities for each commodity, δ_i and φ_i would be selected to minimize the absolute difference between estimated and observed flows, or $\min Z = \left|\hat{y}_i^{mn} - y_i^{mn}\right|$. Because of the gaps in the BTS CFS data however, we do not use observed interregional flows. We do make use of the BTS commodity-specific summary data to generate an observed flow estimate by using a Box-Cox regression specification to estimate the distance decay function for each commodity. The coefficient values derived from estimates of these functions are then used to generate synthetic "observed" flows corresponding to state centroid interregional distances as shown in equation 2,

$$F_i^{mn} = \left[\begin{array}{l} \left(\hat{\beta}_1 + \hat{\beta}_2 \dfrac{\left(\left|d_{mn} - str_m + \min(s, str_n)\right|\right)^{\lambda-1}}{\lambda} \right)^{\frac{\lambda+1}{\lambda}} \\ -\left(\hat{\beta}_1 + \hat{\beta}_2 \dfrac{\left(\left|d_{mn} - str_m - \min(s, str_n)\right|\right)^{\lambda-1}}{\lambda} \right)^{\frac{\lambda+1}{\lambda}} \end{array} \right] * X_r \qquad (2)$$

where F_i^{mn} is the regression-generated (synthetically observed) commodity flow from region *m* to region *n*, d_{mn} represents interregional distance, *str* is the distance from the population centroid to the region border (essentially, state radius), *s* is the size of buffer around interregional "point-to-point" distances, and X_r represents domestic export shares derived from IMPLAN.

With this first step complete, δ_i and φ_i can be calibrated by minimizing the squared percentage error between logit-predicted and regression-generated flows as shown in equation 3,

$$\underset{\delta,\varphi}{Min} \sum_m \sum_n \left(\frac{\hat{Y}_i^{mn} - F_i^{mn}}{F_i^{mn}} \right)^2 \qquad (3)$$

where $\hat{Y}_i^{mn}$ is the predicted flow of commodity i from region m to region n, and F_i^{mn} is the regression-generated commodity flow from region *m* to region *n*. Having calculated commodity-specific values for δ_i and φ_i, the aggregate commodity trade flow distributions in the interregional SAM can be derived by applying the generalized function (2.1) to IMPLAN domestic export estimates from the single-region SAMs. The procedure described generates considerable variation in interaction parameters across commodities. Depending on the commodity, both population and distance can be very important flow determinants or have virtually no effect on flow determination.

2.3 Sector Specific Interregional Commodity Flows

The export distributions for each commodity are first used to apportion the IMPLAN generated domestic export matrices to destination regions. This apportionment is applied equally to commodities exported by institutions and by industries. The export distributions are then unstandardized by IMPLAN export estimates, and normalized by column sum. The result is a set of commodity specific import distributions by region. That is, entries in the new table correspond to the proportion of regional domestic imports that originate in each other region. This new table is then used to apportion aggregate commodities imported by industries and institutions to regions of origin. Because it was derived from the actual export distributions, its use assures consistency between exports from region r to region s and imports by region s from region r (which appear in two separate partitions in the interregional SAM).

3. Foundational Framework

Having presented a general summary of the data and method used in constructing the interregional trade estimates we turn now to examining the overall motivation for this study. We are attempting to further establish a validation framework for the estimates provided by the method. This would allow for the determination of the relative weaknesses of the estimation technique and identify areas for improvements. In addition, we seek to examine the output with an eye towards potentially finding consistent patterns that might either aid in developing the method further or identify areas of weakness.

3.1 Interregional Trade Estimates

General attempts to validate the estimates of interregional trade flows is difficult as there are few other data sets or methods for comparison. Among those that we may examine are the Commodity Flow Survey (CFS) itself, but as mentioned previously it is a difficult data set to work with due to the large number of suppressed values in various sectors. In addition since there is at least some relationship between our method and the CFS, it does not serve well as a comparative data set. We may also consider the estimates obtainable within the Bureau of Transportation Statistics Freight Analysis Framework (FAF), which are the result of a REBEE proprietary estimation/collection method with limited documentation. We could examine the model results against purely theoretical estimators such as Regional Purchase Coefficients (RPC), however these have clearly documented shortcomings and would therefore serve as less than adequate validation instruments. Finally we could compare our estimates to those obtainable from other methods in the literature. Our validation attempts therefore will focus on a comparison our estimates with Liu and Vilain (2004) JTS paper using the Vilain et. al. (1999) method, which is in essence a weighted and balanced LQ transformation of commodity by industry IO model, with the advantage that the framework is flexible enough to model sub-state regions. We will also provide comparison with those regional overlaps where FAF data is available. There are several limitations within this proposed structure, however there seems little better alternative.

3.2 Data

The first consideration is the availability of data for comparison. The FAF is currently available on 2001-2002 database, our model estimates are currently available for the year 2001 as well. Liu and Vilain originally estimated and compared their values to the 1993 CFS, however for this paper their data was re-estimated using most recent CFS. Additionally. Liu and Vilain's method is based on tonnage not dollar value. This is not a problem for FAF comparisons as tonnage values are provide within the dataset. Our method produces dollar values of goods, which were converted to tonnage using CFS commodity-value-per-metric-ton relationships.

Three respective areas were chosen as representative of several types of trading areas. California was chosen as a relatively balanced economy with trade in most sectors, but with particular strength in agriculture and the intangible knowledge based sectors. Ohio was chosen as an example of a manufacturing and consumer good warehousing and distribution heavy trading partner. Finally, Pennsylvania was selected as a state with blended components of both previously selected states, namely agriculture, manufacturing and intangible services. In addition these states were also ones that Lui and Vilain modeled in their paper using 1993 CFS data, thus we could compare our ability to reproduce their estimates before updating them to the most recent data for comparison with our ISAG method.

3.3 Error in ISAG Estimates

The results for the validation exercise can be seen in Tables 1-4. The tables present comparisons for each of the states chosen between the FAF, Lui and Vilain's method the Jackson et al. ISAG method. Percentage difference is given for each of the estimates as well as an overall average difference rate and an absolute overall difference value.

Several results present themselves as one examines the tables. Given the effect of cross hauling we would expect a method that employs LQ to form a relative upper bound on the estimates of interregional trade. As can be observed, our estimates of trade flows fall comfortably within this expectation. Comparing ISAG estimates with Liu and Vilain(2004) we see that overall our estimates are reasonably smaller magnitude than the ones they calculate. This is true for almost all sectors and examined states. The ISAG method we employ is cost/time effective- produces results that are different than the less complex and more straightforward estimation technique they employ.

When examining Table 4 we observe that the overall error of the ISAG method vs. the FAF is not too bad. Sectors that over/under estimate severely are relatively consistent and are characterized by unique final demand such as Ordnance, specialized use/make such as Electrical and machining equipment, or high transportability and cross hauling, such as Apparel. Comparisons with the FAF are unfortunately the only benchmark that we have at this point so the question naturally arises about the relative reliability of the FAF estimates. Given that the data and method that is used to construct those estimates is an unknown quantity we are left concluding that either the FAF or the ISAG estimates are reasonably close to argue that either one may represent a more realistic estimate of the true interregional trade of these three states.

4. Summary and Discussion

This paper has examined the relative effectiveness of an approach to the construction of an interregional SAM for the US, using IMPLAN data as a foundation and incorporating commodity flow data from the US Bureau of Transportation Statistics. The export distribution method provides a generalized function for each commodity, and in so doing, overcomes major obstacles in the use of the CFS data while still taking advantage of the information that is available. The method generates an interregional SAM that is consistent from an accounting perspective, both within each

Table 1. California Trade with US Estimates

Sector	FAF	Lui &Vilain	ISAG	FAF vs L & V	FAF vs ISAG
Apparel	775.00	811.90	589.88	4.76%	-23.89%
Chemicals	12163.58	13081.72	12060.03	7.55%	-0.85%
Clay, conc, glass	2754.47	4312.71	2060.44	56.57%	-25.20%
Elec, mach, eqp.	1365.89	1978.83	952.35	44.88%	-30.28%
Fab Metal	6585.64	4253.96	5815.16	-35.41%	-11.70%
Farm	6138.08	9413.82	5901.116	53.37%	-3.86%
Food	30209.38	32673.53	31425.17	8.16%	4.02%
Forest + Fish	47.42	10.44	51.87	-77.98%	9.38%
Furniture	1002.43	886.30	913.56	-11.58%	-8.87%
Inst, optics, clocks	406.09	438.58	381.66	8.00%	-6.02%
Leather	121.55	127.92	115.87	5.24%	-4.67%
Lumber, wood	3085.23	4131.27	2808.23	33.90%	-8.98%
Machinery	1235.17	1553.31	1182.74	25.76%	-4.25%
Misc Manuf.	609.37	749.24	659.92	22.95%	8.30%
Ordnance	105.75	6.53	62.98	-93.83%	-40.44%
Primary Metal	8421.05	6367.25	8532.21	-24.39%	1.32%
Pulp paper	5782.41	6916.78	5569.22	19.62%	-3.69%
Rubber	1670.66	2203.35	1728.74	31.88%	3.48%
Textiles	1429.71	1272.67	1421.2	-10.98%	-0.60%
Tobacco	15.47	24.80	14.21	60.35%	-8.12%
Transport	4448.82	3444.69	4547.37	-22.57%	2.22%
Waste/Scrap	151.95	452.94	197.3	198.08%	29.84%
AVG.				13.83%	-5.58%
Mean Absolute Difference				38.99%	10.91%

* Values in thousands of metric tons.

Table 2. Ohio Trade with US Estimates

Sector	FAF	Lui & Vilain	ISAG	FAF vs L & V	FAF vs ISAG
Apparel	317.47	372.01	282.5	17.18%	-11.02%
Chemicals	11427.09	12546.54	10714.45	9.80%	-6.24%
Clay, conc, glass	3545.83	5101.11	3798.38	43.86%	7.12%
Elec, mach, eqp.	1058.38	1209.79	754.75	14.31%	-28.69%
Fab Metal	2162.69	2555.92	1911.71	18.18%	-11.61%
Farm	4310.00	3374.20	4518.11	-21.71%	4.83%
Food	16645.82	17851.28	16410.53	7.24%	-1.41%
Forest + Fish	18.05	15.66	17.86	-13.23%	-1.07%
Furniture	797.20	841.21	659.92	5.52%	-17.22%
Inst, optics, clocks	264.40	314.87	310.47	19.09%	17.43%
Leather	50.50	44.38	57.86	-12.12%	14.57%
Lumber, wood	1919.01	3810.17	1708.59	98.55%	-10.96%
Machinery	918.55	845.83	798.38	-7.92%	-13.08%
Misc Manuf.	665.33	425.53	649.67	-36.04%	-2.35%
Ordnance	33.94	13.05	12.1	-61.54%	-64.35%
Primary Metal	5122.31	4975.80	5447.37	-2.86%	6.35%
Pulp paper	6364.09	7664.72	6106.94	20.44%	-4.04%
Rubber	558.68	1334.02	523.01	138.78%	-6.38%
Textiles	414.91	365.48	418.67	-11.91%	0.91%
Tobacco	16.01	18.27	17.88	14.13%	11.67%
Transport	2271.81	1837.86	2267.21	-19.10%	-0.20%
Waste/Scrap	698.72	1151.27	782.92	64.77%	12.05%
AVG				12.97%	-4.71%
Mean Abs. Difference				29.92%	11.52%

* Values in thousands of metric tons.

Table 3. Pennsylvania Trade with US Estimates

Sector	FAF	Lui & Vilain	ISAG	FAF vs L & V	FAF vs ISAG
Apparel	230.01	302.83	170.667	31.66%	-25.80%
Chemicals	5761.35	7595.54	5605.2045	31.84%	-2.71%
Clay, conc, glass	2746.32	3366.37	2660.511	22.58%	-3.12%
Elec,mach,eqp.	484.98	788.40	684.0183	62.56%	41.04%
Fab Metal	2024.79	2241.47	1545.76905	10.70%	-23.66%
Farm	4382.00	4944.48	4737.768	12.84%	8.12%
Food	12272.12	13223.99	14418.0435	7.76%	17.49%
Forest+Fish	110.73	80.93	121.66035	-26.91%	9.87%
Furniture	533.06	496.01	457.0545	-6.95%	-14.26%
Inst, optics, clocks	110.15	127.92	95.592	16.14%	-13.21%
Leather	43.05	30.02	46.1265	-30.26%	7.15%
Lumber,wood	1796.62	5316.49	1782.7215	195.92%	-0.77%
Machinery	814.77	728.36	835.023	-10.61%	2.49%
Misc Manuf.	331.29	319.80	262.1535	-3.47%	-20.87%
Ordnance	32.82	0.00	16.989	-100.00%	-48.23%
Primary Metal	7389.26	8360.45	7888.314	13.14%	6.75%
Pulp paper	3154.37	5758.98	3640.6335	82.57%	15.42%
Rubber	1632.29	1200.88	1754.823	-26.43%	7.51%
Textiles	400.27	681.37	457.0545	70.23%	14.19%
Tobacco	17.06	19.58	19.5405	14.78%	14.55%
Transport	1822.82	1869.19	1906.2435	2.54%	4.58%
Waste/Scrap	358.72	917.63	434.1435	155.81%	21.03%
AVG				23.93%	0.80%
Mean Absolute Difference				42.53%	14.67%

* Values in thousands of metric tons.

Table 4. Comparison of Estimation Differences vs. FAF values

Sector	California Percent Difference	Ohio Percent Difference	Pennsylvania Percent Difference
Apparel	-23.89%	-11.02%	-25.80%
Chemicals	-0.85%	-6.24%	-2.71%
Clay, conc, glass	-25.20%	7.12%	-3.12%
Elec, mach, eqp.	-30.28%	-28.69%	41.04%
Fab Metal	-11.70%	-11.61%	-23.66%
Farm	-3.86%	4.83%	8.12%
Food	4.02%	-1.41%	17.49%
Forest + Fish	9.38%	-1.07%	9.87%
Furniture	-8.87%	-17.22%	-14.26%
Inst, optics, clocks	-6.02%	17.43%	-13.21%
Leather	-4.67%	14.57%	7.15%
Lumber, wood	-8.98%	-10.96%	-0.77%
Machinery	-4.25%	-13.08%	2.49%
Misc Manuf.	8.30%	-2.35%	-20.87%
Ordnance	-40.44%	-64.35%	-48.23%
Primary Metal	1.32%	6.35%	6.75%
Pulp paper	-3.69%	-4.04%	15.42%
Rubber	3.48%	-6.38%	7.51%
Textiles	-0.60%	0.91%	14.19%
Tobacco	-8.12%	11.67%	14.55%
Transport	2.22%	-0.20%	4.58%
Waste/Scrap	29.84%	12.05%	21.03%
Average	**-5.58%**	**-4.71%**	**0.80%**
M.A.D.	**10.91%**	**11.52%**	**14.67%**

regional SAM and for the interregional modeling system as a whole.

The overall comparison of this method with others in the literature is largely a positive one. The ISAG method yields results that are relatively more consistent than other methods when compared to an ultimately unknown truth, providing reasonable estimates in relation to the FAF, however it is impossible to really say which one of the estimates are actually true as there is no known baseline for comparison. Therefore the fact that the ISAG estimates are close to the FAF estimates which are derived using methods that are unclear due to their proprietary nature might be considered a reasonably positive outcome. This is particularly true as the ISAG method allows for substate region estimation that is unavailable within the FAF.

Acknowledgments

The authors gratefully acknowledge the support of the Bureau of Economic Analysis, National Science Foundation Grant BCS-0318080, and helpful comments of colleagues. This paper was originally presented at the joint 2005 meetings of the Mid-continent Regional Science Association and the Southern Regional Science Association in Washington, DC.

References

Canning, Patrick & Wang, Zhi. 2005. Flexible mathematical programming model to estimate interregional input–output accounts. *Journal of Regional Science* 45(3): 539-563.

Celik, H. Murat and Jean-Michel Guldmann. 2002. Spatial interaction modeling of interregional commodity flows. Paper Presented at the 42nd European Congress of the Regional Science Association, Dortmund, Germany.

[Jack] Faucett Associates, Inc. 1983. *The Multiregional Input-Output Accounts, 1977: Introduction and Summary, Vol.1 (Final Report)*. Prepared for the US Department of Health and Human Services, Washington, D.C. (Jack Faucett Associates Inc., Chevy Chase, MD).

Hewings, Geoffrey J.D., Michael Sonis, Jiemin Guo, Philip R. Israilevich, and Graham R. Schindler. 1998. The hollowing-out process in the Chicago economy, 1975-2015. *Geographical Analysis* 30(3): 217-33.

Hitomi, Kazumi., Yasuhide Okuyama, and Geoffrey J.D. Hewings. 2000. The role of interregional trade in generating change in the interregional Leontief Inverse in Japan, 1980-1990. *Economic Systems Research* 12(4): 515-537.

Horiba, Yutaka. 2000. U.S. interregional migration and trade. Paper presented in the Murphy Institute Conference on the Political Economy of Migration, Murphy Institute of Political Economy, Tulane University: March 24-25, 2000.

Isard, Walter. 1951. Interregional and regional input-output analysis: A model of a space economy. *Review of Economics and Statistics* 33(4): 318-328.

Jackson, R. 2002. Constructing US interregional SAMs from IMPLAN data: Issues and methods. Regional Research Institute Working Paper 2002-13, West Virginia University.

Jackson, R., W. Schwarm, Y. Okuyama, and S. Islam. (forthcoming). A method for constructing commodity by industry flow matrices. *Annals of Regional Science.*

Liu, L. N., and P. Vilain. 2004. Estimating commodity inflows to a substate region using input-output data: Commodity flow survey accuracy tests. *Journal of Transportation and Statistics* 7(1): 23-37.

Miller, R.E., and G. Shao. 1990. Spatial and sectoral aggregation in the commodity-industry multiregional input-output model. *Environment and Planning A* 22: 1637-1656.

Polenske, Karen R. 1972. The implementation of a multiregional input-output model for the United States. In: A.P. Carter and A. Brody (eds.) *Contributions to Input-Output Analysis*, Amsterdam. Elsevier-North Holland: 171-189.

Polenske, Karen R. 1980. *The US Multiregional Input-Output Accounts and Model*. Lexington, MA: Lexington Books.

Pyatt, G., and J.I. Round. 1983. Improving the macroeconomic database: A SAM for Malaysia, 1970. World Bank Staff Working Paper 646.

Pyatt, G., and E. Thorbecke. 1976. *Planning Techniques for a Better Future*. Geneva: International Labor Office.

Round, J.I. 1985. Decomposing multipliers for economic systems involving regional and world trade. *Economic Journal* 95: 383-399.

Round, J.I. 1995. A SAM for Europe: Social accounts at the regional level revisited. In: G.J.D. Hewings and M. Madden (eds.) *Social and Demographic Accounting*, Cambridge, UK; Cambridge University Press: pp. 15-40.

Stone, Richard. 1961. Social accounts at the regional level. In: Walter Isard and J.H. Cumberland (eds.) *Regional Economic Planning.* Paris; Organization for European Economic Cooperation: pp. 263-269.

US Army Corps of Engineers. 1994. *Regional Economic Development: Red River Waterway Project Reevaluation Study In-Progress Review.* May 1994.