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# The Effects of Interregional Trade Flow Estimating Procedures on Multiregional Social Accounting Matrix Multipliers

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**Abstract.** Social accounting matrix (SAM) models have become standard methods to provide quantitative economic impact evaluation. SAM models and methods have a wide body of literature and dates back several decades. In recent years there has been a growing interest in using interregional and multiregional SAM models. IMPLAN provides data necessary, in a convenient format, to construct single-region SAM models. Procedures of the use of IMPLAN data in concert with BEA's "journey-to-work" commuting flows and data from the Commodity Flow Survey (CFS) collected by the Census Bureau and compiled by the Bureau of Transportation Statistics to construct state-level multiregional SAM models has been demonstrated. However, little research exists concerning the creation of multiregional SAM models at geographic scales lower than states, especially the roll that interregional trade plays in the accuracy of these models. This paper evaluates sensitivity of multiregional SAM multipliers to the procedures used to estimate interregional trade flows.

## 1. Introduction

Social accounting matrix (SAM) models are important quantitative economic evaluation tools. These models permit an assessment of different policy decisions over an entire economic system using the effects of important economic aggregates and agents. There is a wide body of literature on SAM models and methods that date back several decades. In recent years there has been a growing interest in using interregional and multiregional SAM models.

IMPLAN provides data in a convenient format that are necessary to construct single region input-output and SAM models. In order to compile a working multiregional input-output or SAM model, however, a set of interregional trade flows (or coefficients) have to be estimated. The use of IMPLAN data in concert with data from the Commodity Flow Survey (CFS)—collected by the Census Bureau and compiled by the Bureau of Transportation Statistics—to construct state-level multiregional SAM model has been demonstrated by Jackson (2002). However, little research exists concerning the creation of multiregional models at geographic scales lower than states, especially the roll that interregional trade plays.

This paper evaluates the effects of using two interregional trade flow estimating procedures on multiregional SAM multipliers. One uses a variation of location quotient to estimate domestic exports. The other uses the regional purchase coefficients that IMPLAN produces to estimate domestic imports. The estimated domestic imports and exports for both sets of trade flow estimates are balanced to fit within IMPLAN's accounting framework. The techniques employed in this paper are applied to 238, 3-region multiregional SAM models.

Section 2 provides the motivation for compiling multiregional SAM models and their use in measuring the performance of a major federal government agency. The information system and multiregional SAM models that were developed for the agency are described. Section 3 of the paper explains the two techniques that were used to estimate the interregional commodity trade flows—based on location quotients and on regional purchase coefficients. Comparisons of the variability in the multipliers and impact estimates that result by using different trade flow estimating procedures are shown in section 4. Finally, section 5 provides several conclusions and recommendations.

## 2. Measuring Development Performance

The mission of the United States Department of Agriculture Rural Development program (formerly known as the Rural Business-Cooperative Services or RBS) is to promote a dynamic business environment in rural America. Rural Development uses a variety of loan and grant programs to help facilitate projects that create or preserve quality jobs and enhance the quality of life in rural communities across the nation. Rural Development works in partnership with the private sector and community-based organizations to provide financial assistance to meet business and credit need in under-served areas.

Recently, the USDA Economic Research Service has entered into a cooperative agreement with the Community Policy Analysis Center (CPAC) and the Rural Policy Research Institute (RUPRI) to develop an information system and set of multiregional SAM models to assess the effectiveness of the Rural Development loan and grant programs (Robinson and Johnson, 2005). The resulting information system is called the Rural Development Socio-Economic Benefits Assessment System (SEBAS). SEBAS has to date been developed for California, Montana, New Hampshire, North Carolina, and Vermont.

### 2.1 Expanding criteria for measuring Performance

Currently, Rural Development reports jobs either created or retained by its loan and grant recipients. "Direct" jobs increases are used by many federal and state agencies as a measure of their performance. However, the number of direct jobs created or retained is, in isolation, a poor indicator of economic change and performance. For example, reporting direct jobs treats part-time and full-time jobs equally despite the fact that full-time jobs generate more income, more security and support families better. Job estimates should be adjusted to reflect full-time equivalency (FTE). This provides a performance measure that doesn't ignore seasonal and part-time work but would give greater weight to projects that produce full-time jobs compared to part-time jobs.

But even full-time employment is too narrow a measure of economic performance. With SEBAS, Rural Development is able to track and report contributions to gross domestic product (GDP) from its projects.[1] GDP is the broadest available measure of income and the most widely used measure of macroeconomic performance. It is the sum of four impact variables estimated by SEBAS: employee compensation (wages and salaries plus employee benefits), proprietors' income, other property-type income (profits, dividends, interest, rents, etc.), and indirect business taxes.

Direct changes in jobs, employment and contributions to GDP are perhaps the best measures of change at a national accounting level. But at the local and regional level, linkages between sectors are critical determinants of change in the economic well-being. Total economic effects (direct and indirect) reflect the impact of programs on the activities of existing firms in a local economy.

Finally, the "quality" of the jobs created by Rural Development loans and grants should be a key indicator of its performance. Those employers that pay higher wages, more benefits, and contribute to the tax base, and those that indirectly stimulate existing firms that pay higher wages, more benefits and contribute to the tax base, will contribute more to the local, rural community welfare. This factor can be measured by the ratio of GDP to FTE or the "GDP per worker" ratio.

### 2.2 What SEBAS Does and Does Not Do?

SEBAS offers an opportunity to consider a much wider and richer array of assessment criteria. The array is "wider" because SEBAS tracks a greater number of possible assessment criteria than just the number of jobs created or retained. The array is "richer" for two important reasons. First, SEBAS not only considers the direct effects of RBS' activity, but it also addresses the indirect effects of the loan and grant programs. Second, SEBAS provides an evaluation of the geographic dispersion of Rural Development's social and economic effects by measuring the impacts at the county, region and state levels.

But SEBAS is more than these key indicators. In addition to the indicators listed above, SEBAS also generates a variety of economic impact measures that may be useful when more detailed and inclusive accounts of particular projects are desired. These measures include such evaluation information as business sales, personal income, indirect business taxes, an implicit wage for the overall impact, and federal, state, and local taxes. SEBAS also generates estimates of how Rural Development loans and grants affect the distribution of household income, the occupational distribution of employment impacts, and the generation of various types of tax revenues.

SEBAS focuses on the mission of the Rural Development, which is to improve the quality of life in rural

[1] GDP is defined here as value added—the sum of employee compensation, proprietors' income, other property type income, and indirect business taxes.

areas. It is not intended to measure the impacts of Rural Development programs on the national economy. This is why the impacts are limited to the county, region and state. Beyond the region or state, economic impacts are less certain, and more likely to involve shifts from place to place rather than new economic activities.

SEBAS' benefits assessment is predicated on the accuracy of the job and economic activity estimates entered into the program. These jobs should represent either new jobs or activity for the region or the jobs and economic activity that would otherwise leave the area without the loan or grant. SEBAS, does not itself, assure the accuracy of this information. It does introduce a new process for monitoring the performance of economic activity associated with Rural Development loans and grants and for measure the impacts of these reported activities.

### 2.3. Structure of Multiregional SAM Models

SEBAS models have a multiregional social accounting matrix (SAM) modeling framework that not only addresses the economic effects of Rural Development loans and grants in the counties where they are issued, it also provides estimates of the effects as they spread to surrounding counties and beyond (within the state). The SEBAS framework consists of a series of interrelated accounts where "what is 'incoming' into one account must be 'outgoing' from another account" (King, 1985). The information within a SAM model reveals much about the economic and social structure of an area for which it is constructed.

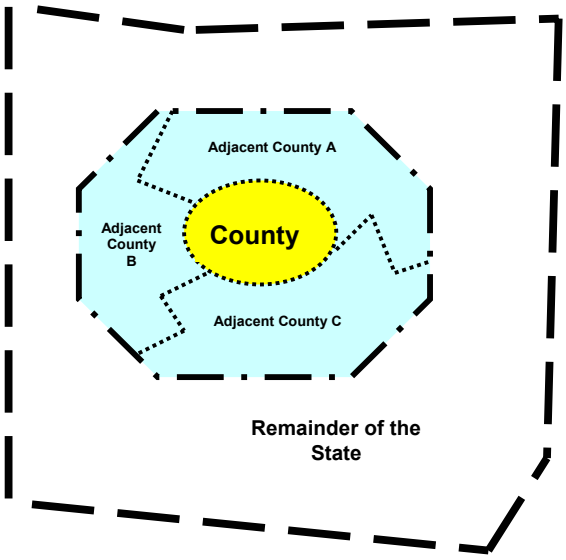



**Figure 1.** Map of a hypothetical rural development impact region

SEBAS SAM models evaluated in this paper were compiled using the IMPLAN CGE (MIG, 1998) for the year 2001 for all counties within the five states of California, Montana, North Carolina, New Hampshire, and Vermont.[2] In all, there are 238 counties in these five states. Each SEBAS multiregional SAM model consists of three geographic sub-areas (Figure 1). One sub-area is the county where a loan or grant is issued. A second sub-area consists of the surrounding adjacent counties. And, a third sub-area is an aggregate of the remaining counties within the same state. The industrial structure of each SEBAS multiregional SAM model is shown in Table 1. Table 2 shows the factors and institutions in the SEBAS SAM models.

Table 3 displays an example of the 27 CGE data files that are created within IMPLAN and available for each model that a user compiles. Figure 2 shows these files arranged in a single region SAM format. Note that the domestic imports by commodity are used to compile the SEBAS multi-region SAM models.[3]

In order to use IMPLAN's single region SAM models to compile a three region SAM first requires that a single region SAM be compiled for each of the three sub-regions. Second, the information in each of the sub-region SAM models need to be rearranged into a multiregional SAM framework (Figure 3).

Note that the information in Figure 2 transfers directly along the main diagonal sub-blocks of Figure 3 and the off-diagonal sub-blocks have to be estimated (the sub-blocks labeled **N**, **O**, and **P**). This happens because we are assuming the same intra-regional trade patterns as IMPLAN. The labor factor payments (labeled **P** in Figure 3) are distributed to the county, adjacent counties, rest of the state, and rest of the nation via the 2000 sector-specific BEA inter-county commuting flows ("journey-to-work" data file).

## 3. Estimating Interregional Trade Flows

The domestic imports (industry and institutional) can be distributed to off-diagonal sub-blocks **N** and **O** using interregional trade coefficients estimated by one of several methods for estimating interregional trade flows. A "location quotient" variant was used to estimate interregional trade flows in the SEBAS SAM models. However, little is known about effects that different methods of estimating trade coefficients can have on the practical aspects of compiling multiregional input-output or SAM models. For example,

[2] The states of New Hampshire and Vermont were treated as if they were one state for modeling purposes.

[3] The current SEBAS models have a county, rest-of-state metropolitan, and rest-of-state non-metropolitan geographic configuration.

**Table 1.** SEBAS multiregional SAM model commodities and sectors

| # | Commodity or Sector | IMPLAN | # | Commodity or Sector | IMPLAN |
|---|---|---|---|---|---|
| 1 | Crops | 001-010 | 28 | Insurance | 427 428 |
| 2 | Livestock | 011-013 | 29 | Real estate | 431 |
| 3 | Forestry and logging | 014 015 | 30 | Utilities | 030-032 495 498 |
| 4 | Fishing, hunting and trapping | 016 017 | 31 | Agriculture and forestry services | 018 |
| 5 | Petroleum and natural gas | 019 | 32 | Mining services | 027-029 |
| 6 | Mined ores | 020-026 | 33 | Printing and publishing services | 136-141 413-417 |
| 7 | Construction | 033-045 | 34 | Internet and data process services | 423 424 |
| 8 | Food, beverages and tobacco products | 046-091 | 35 | Motion picture and sound recording | 418 419 |
| 9 | Textile products | 092-103 | 36 | Broadcasting | 420-423 |
| 10 | Apparel | 104-108 | 37 | Rental and leasing services | 432-436 |
| 11 | Leather and allied products | 109-111 | 38 | Scientific and technical consulting services | 437-450 |
| 12 | Wood products | 112-123 | 39 | Administrative and management support services | 451-459 |
| 13 | Paper products | 124-135 | 40 | Waste management and remediation services | 460 |
| 14 | Refined petroleum and coal products | 142-146 | 41 | Educational services | 461-463 |
| 15 | Chemical products | 147-171 | 42 | Health care services | 464-468 |
| 16 | Plastics and rubber products | 172-181 | 43 | Recreation services | 471-478 |
| 17 | Mineral products | 182-202 | 44 | Hotels and other accomodations | 479 480 |
| 18 | Metal products | 203-256 | 45 | Dining and drinking places | 481 |
| 19 | Nonelectrical machinery and equipment | 257-301 | 46 | Repair and maintenance services | 482-486 |
| 20 | Computers and electronic components | 302-324 | 47 | Personal and laundry services | 487-490 |
| 21 | Electircal appliances and equipment | 325-343 | 48 | Religious, grantmaking and similar organizations | 491-493 |
| 22 | Transportation equipment | 344-361 | 49 | Private households | 494 |
| 23 | Furniture and related products | 362-373 | 50 | Social assistance services | 469 470 |
| 24 | Other manufactured goods | 374-389 | 51 | Post office | 496 |
| 25 | Wholesale and retail trade | 390 401-412 | 52 | Labor compensation | |
| 26 | Transportation | 391-400 497 | 53 | Profits, dividends, rents, interest, etc | |
| 27 | Finance | 425 426 429 430 | 54 | Business taxes | |

| | | Sales and Distributions* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Industry | Commodity | Factor | Institution | Foreign Trade | Domestic Trade | Total Sales and Distributions |
| Payments & Receipts | | 1 | 2 | 3 | 4 | 5 | 6 | |
| 1 | Industry | | Local industry make | | | Industry foreign exports | Industy domestic exports by commodity | Σ |
| 2 | Commodity | Industry use of local commodities | | | Institutional use of local commodities | | | Σ |
| 3 | Factor | Factor incomes | | | | | | Σ |
| 4 | Institution | | Local institutional sales | Factor distributions | Institutional transfers | Institutional foreign exports | Institutional domestic exports | Σ |
| 5 | Foreign Trade | Industry foreign imports | | Foreign factor imports | Institutional foreign imports | Foreign transhipments | | Σ |
| 6 | Domestic Trade | Industry domestic imports by commodity | | Domestic factor imports | Institutional domestic imports by commodity | | | Σ |
| Total Receipts | | Σ | Σ | Σ | Σ | Σ | Σ | |

**Figure 2.** Figure 2: Single region IMPLAN social accounting matrix format

how will the estimated multiregional multipliers be impacted? In order to test the sensitivity of the multiregional multiplier effects to various methods of estimating trade flows (and, therefore, to trade coefficients) an alternative method was used and compared to the location quotient procedure.

Table 2. IMPLAN SAM institutions

| | | |
|---|---|---|
| Factors | F 1 | Employee Compensation |
| | F 2 | Proprietary Income |
| | F 3 | Other Property Income |
| | F 4 | Indirect Business Taxes |
| Institutions | I 01 | Households LT10k |
| | I 02 | Households 10-15k |
| | I 03 | Households 15-25k |
| | I 04 | Households 25-35k |
| | I 05 | Households 35-50k |
| | I 06 | Households 50-75k |
| | I 07 | Households 75-100k |
| | I 08 | Households 100-150k |
| | I 09 | Households 150k+ |
| | I 10 | Federal Government NonDefense |
| | I 11 | Federal Government Defense |
| | I 12 | Federal Government Investment |
| | I 13 | State/Local Govt NonEducation |
| | I 14 | State/Local Govt Education |
| | I 15 | State/Local Govt Investment |
| | I 16 | Enterprises (Corporations) |
| | I 17 | Capital |
| | I 18 | Inventory Additions/Deletions |

Until recently, there were no readily available sources of interregional trade flow accounts. Commodity trade flow surveys were conducted for 1997 and 2002 by the U.S. Bureau of the Census and the results were compiled by the U.S. Bureau of Transportation Statistics. However, state-to-state transport flows by commodity have not been compiled and made available for public release and use. Southworth and Pererson (2000) and Jackson, et al (2004) describe methods of estimating trade flows using data from the commodity flow survey. However, these data only cover commodity flows, not other equally important types of transactions (such as construction, trade, and services).

In lieu of these vital data, Hewings, Okuyama, and Sonis (2001) and Peterson and Beck (2001) have developed two different empirical procedures to estimate interregional trade flows, both for commodities and services. The procedures employ the information used to compile IMPLAN's regional SAM accounts. Trade linkages between regions provide a way for regions to specialize in the production of those commodities for which they have comparative advantages.

**Table 3.** An example of IMPLAN's CGE data file structure

| | | | File Dimension | |
|---|---|---|---|---|
| # | CGE File Name | Information | Rows | Columns |
| 1 | boone CGE Files (Text304) 1x2.dat | Local industry make | 509 | 509 |
| 2 | boone CGE Files (Text304) 1x5.dat | Industry foreign exports (aggregated) | 509 | 1 |
| 3 | boone CGE Files (Text304) 1x6.dat | Industry domestic exports (aggregated) | 509 | 1 |
| 4 | boone CGE Files (Text304) 1x7.dat | Industry foreign exports by commodity | 509 | 509 |
| 5 | boone CGE Files (Text304) 1x8.dat | Industry domestic exports by commodity | 509 | 509 |
| 6 | boone CGE Files (Text304) 2x1.dat | Industry use of locally produced commodities | 509 | 509 |
| 7 | boone CGE Files (Text304) 2x4.dat | Institutional use of locally produced commodities | 509 | 18 |
| 8 | boone CGE Files (Text304) 3x1.dat | Factor incomes by industry | 4 | 509 |
| 9 | boone CGE Files (Text304) 4x2.dat | Local institutional sales by commodity | 18 | 509 |
| 10 | boone CGE Files (Text304) 4x3.dat | Institutional factor distributions | 18 | 4 |
| 11 | boone CGE Files (Text304) 4x4.dat | Institutional transfers | 18 | 18 |
| 12 | boone CGE Files (Text304) 4x5.dat | Institutional foreign exports (aggregated) | 18 | 1 |
| 13 | boone CGE Files (Text304) 4x6.dat | Institutional domestic exports (aggregated) | 18 | 1 |
| 14 | boone CGE Files (Text304) 4x7.dat | Institutional foreign exports by commodity | 18 | 509 |
| 15 | boone CGE Files (Text304) 4x8.dat | Institutional domestic exports by commodity | 18 | 509 |
| 16 | boone CGE Files (Text304) 5x1.dat | Industry foreign imports (aggregated) | 1 | 509 |
| 17 | boone CGE Files (Text304) 5x3.dat | Foreign factor imports | 1 | 4 |
| 18 | boone CGE Files (Text304) 5x4.dat | Institutional foreign imports | 1 | 18 |
| 19 | boone CGE Files (Text304) 5x5.dat | Foreign transhipments | 1 | 1 |
| 20 | boone CGE Files (Text304) 6x1.dat | Industry domestic imports (aggregated) | 1 | 509 |
| 21 | boone CGE Files (Text304) 6x3.dat | Domestic factor imports | 1 | 4 |
| 22 | boone CGE Files (Text304) 6x4.dat | Institutional domestic imports (aggregated) | 1 | 509 |
| 23 | boone CGE Files (Text304) 7x1.dat | Industry foreign imports by commodity | 509 | 509 |
| 24 | boone CGE Files (Text304) 7x4.dat | Institutional foreign imports by commodity | 509 | 18 |
| 25 | boone CGE Files (Text304) 8x1.dat | Industry domestic imports by commodity | 509 | 509 |
| 26 | boone CGE Files (Text304) 8x4.dat | Instiutional domestic imports by commodity | 509 | 18 |
| 27 | boone CGE Files (Text304) EMP.dat | Industry employment | 509 | 1 |

| Payments & Receipts* | | | Sales and Distributions* | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Endogenous Sectors for the Three Regions | | | | | | | | | | | | Exogenous Sectors | | | |
| | | | County | | | | Surrounding Counties | | | | Rest of State | | | | | | | |
| | | | Ind | Com | LF | HH Inst | Ind | Com | LF | HH Inst | Ind | Com | LF | HH Inst | NLF & Commuters | NHH INST | Foreign Trade | Domestic Trade |
| Endogenous Sectors for the Three Regions | County | Industry (IND) | | Local industry make | | | | | | | | | | | | | Foreign industry exports | Domestic industry exports |
| | | Commodity (COM) | Local industry use | | | HH inst use | N | | | O | N | | | O | | NHH inst use | | |
| | | Labor Factor (LF) | P | | | | P | | | | P | | | | | | | |
| | | Household (HH) institution | | HH inst sales | HH inst factor dist | HH inst transfers | | | | | | | | | | HH/NHH inst transfers | Foreign HH inst exports | Domestic HH inst exports |
| | Surrounding Counties | Industry (IND) | | | | | | Local industry make | | | | | | | | | Foreign industry exports | Domestic industry exports |
| | | Commodity (COM) | N | | | O | Local industry use | | | HH inst use | N | | | O | | NHH inst use | | |
| | | Labor Factor (LF) | P | | | | P | | | | P | | | | | | | |
| | | Household (HH) institution | | | | | | HH inst sales | HH inst factor dist | HH inst transfers | | | | | | HH/NHH inst transfers | Foreign HH inst exports | Domestic HH inst exports |
| | Rest of State | Industry (IND) | | | | | | | | | | Local industry make | | | | | Foreign industry exports | Domestic industry exports |
| | | Commodity (COM) | N | | | O | N | | | O | Local industry use | | | HH inst use | | NHH inst use | | |
| | | Labor Factor (LF) | P | | | | P | | | | P | | | | | | | |
| | | Household (HH) institution | | | | | | | | | | HH inst sales | HH inst factor dist | HH inst transfers | | HH/NHH inst transfers | Foreign HH inst exports | Domestic HH inst exports |
| Exogenous Sectors | Non-Labor Factor (NLF) & Out-of-State Commuters | | NL factor & commuter income | | | | NL factor & commuter income | | | | NL factor & commuter income | | | | | | | |
| | Non-Household (NHH) institution | | | NHH inst sales | NHH inst factor dist | NHH/HH inst transfers | | NHH inst sales | NHH inst factor dist | NHH/HH inst transfers | | NHH inst sales | NHH inst factor dist | NHH/HH inst transfers | | | Foreign NHH inst exports | Domestic NHH inst exports |
| | Foreign Trade | | Foreign industry imports | | Foreign lab factor imports | Foreign HH inst imports | Foreign industry imports | | Foreign lab factor imports | Foreign HH inst imports | Foreign industry imports | | Foreign lab factor imports | Foreign HH inst imports | Foreign non-lab factor imports | Foreign NHH inst imports | Foreign transhipments | |
| | Domestic Trade | | N | | Domestic lab factor imports | O | N | | Domestic lab factor imports | O | N | | Domestic lab factor imports | O | Domestic non-lab factor imports | Domestic NHH inst imports | | |

*Values in millions of dollars

**Figure 3.** Multiregional SAM framework with required estimated values

### 3.1 Location Quotients

Hewings, Okuyama, and Sonis (2001) use an application of location to estimate industry trade coefficients between sub-regions of their Chicago metropolitan area multiregional input-output model. The location quotient of any sector $i$ in region $r$ ($LQ_i^R$) is

$$LQ_i^R = \frac{E_i^R / E_\bullet^R}{E_i^B / E_\bullet^B} \qquad (1)$$

$E_i^R$ is sector $i$'s employment in region $R$, $E_\bullet^R$ is total employment in region $R$, $E_i^B$ is employment in sector $i$ in a benchmark economy, and $E_\bullet^B$ is total employment in the benchmark economy. Usually, the benchmark economy is taken to be the nation or state.

One very old interpretation of the location quotient relates to regional trade. When a location quotient is greater than one, the local economy has a sector producing relatively more than the sector does in the benchmark economy. The implication is that this sector must be producing more than the local economy needs and, therefore, it is exporting some proportion of the goods or services produced by the sector. Alternatively, if a sector's location quotient is less than or equal to one, the implication is that the sector is either not producing enough to meet local demand for its products or is just satisfying local demand. Either way, these sectors are not exporting the goods or services that they produce.

An export share for a sector is the proportion of its production that is exported. This can be estimated using location quotients (Isserman, 1977). For sectors with location quotient greater than one the export share is

$$ex_i^R = \left(1 - \frac{1}{LQ_i^R}\right) \qquad (2)$$

The export share indicates the portion of a sector's employment that is devoted to producing exports and can be an estimate of that proportion of a sector's pro-

duction that is exported if the relationship between output and employment is constant for any sector.

The location quotient can be applied to areas with sub-regions where the area is used as the benchmark economy. For example, for an area with two sub-regions ***R*** and ***S*** the location quotient for sector ***i*** in region ***R*** having two sectors is

$$LQ_i^R = \frac{e_i^R \Big/ \left(e_1^R + e_2^R\right)}{\left(e_i^R + e_i^S\right) \Big/ \left(e_1^R + e_2^R + e_1^S + e_2^S\right)}. \qquad (3)$$

Here $e$ is defined to be employment shares over all industries of both regions, or $e_1^R + e_2^R + e_1^S + e_2^S = 1$. The export share for sector ***i*** in region ***R*** is

$$ex_i^R = 1 - \frac{1}{LQ_i^R} = 1 - \frac{\left(e_1^R + e_2^R\right)\left(e_i^R + e_i^S\right)}{e_i^R}. \qquad (4)$$

Because the benchmark economy here is defined to be the area with two sub-regions the exports of one sub-region are the imports of the other sub-region. Multiplying equation [4] by the sector's total commodity supply ($TCS_i^R$) will provide an estimate of industry exports between the sub-regions of the area,

$$EXP_i^{RS} = TCS_i^R \times ex_i^R. \qquad (5)$$

Conversely, equation [5] also estimates the imports of goods produced by sector ***i*** in region ***R*** that are purchased by consumers in region ***S*** (imports for region ***S***).

### 3.2 Regional Purchase Coefficients

Because the sub-regions may be trading a commodity amongst them selves, Peterson and Beck (2001) note that imports of a commodity into a region must be less than or equal to the sum of the imports for that commodity for its sub-regions. If there is trade between the sub-regions, then it should not be considered an import from the aggregate region's perspective.

A regional purchase coefficient (***RPC***) is a measure of the proportion of commodity consumption that is locally produced; or, by implication, imported from locations outside the region. Although a commodity indicator is not shown in the following formulations, it is implied that they refer to the same commodity. The value of a ***RPC*** varies between zero and one ($0 \le RPC \le 1$). An ***RPC*** equal zero occurs when either a commodity consumed locally is not produced locally or when the local production of a commodity to totally exported (i.e., all consumption is imported). An ***RPC*** equal to one occurs when local demand for a commodity is entirely met by local producers (i.e., no imports). An estimate of the value of the import of a commodity is found by multiplying its local demand by the difference between one and the ***RPC*** or

$$IMP^R = TCD^R \times (1 - RPC^R) \qquad (6)$$

For any given region ***r*** and a particular commodity, ***IMPR*** is the value of imports a, $TCD^R$ is the value of total commodity demand, and $RPC^R$ is the regional purchase coefficient.

Imports of a particular commodity for an aggregate region ***ΣRS*** and its two sub-areas ***R*** and ***S*** are, respectively, $IMP^{\Sigma RS}$, $IMP^R$, and $IMP^S$. For two sub-regions (***R*** and ***S***) and their aggregate area (***ΣRS***) total imports between ***R*** and ***S*** are[4]

$$IMP^{RS} + IMP^{SR} = IMP^R + IMP^S - IMP^{\Sigma RS} \qquad (7)$$

$IMP^{SR}$ is the amount of commodity imports produced in region ***S*** and purchased by consumers in region ***R*** and $IMP^{RS}$ is the amount commodity imports produced in region ***R*** and purchased by consumers in region ***S***. The issue with this procedure is that it estimates total imports between regions ***R*** and ***S*** and needs to be parsed into its respective components. On method of parsing of the total imports between ***R*** and ***S*** is based their shares of total commodity demand

$$IMP^{SR} = \frac{TCD^R \times (IMP^{SR} + IMP^{RS})}{(TCD^R + TCD^S)} \qquad (8)$$

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[4] To be consistent with the import relationship between an aggregate regional and its sub-areas the ***RPC*** for a particular commodity of a set of sub-regions must be consistent with the corresponding ***RPC*** for their aggregate region in a certain way. For a particular commodity the ***RPC*** for the aggregate region (say ***ΣRS*** composed of two sub-regions ***R*** and ***S***) must be greater than or equal to the weighted average of the ***RPC***s for the component sub-areas, or

$$RPC_{\Sigma RS} \ge \frac{W^R \times RPC^R + W^S \times RPC^S}{W^R + W^S}.$$

***WR*** and ***WS*** are weighting factors for regions ***R*** and ***S***. Appropriate weighting factors would be measures of commodity demand such as total gross commodity demand for each sub-region. Further development of the regional purchase coefficient method of estimating interregional trade flows is provided in the Appendix.

$$IMP^{RS} = \frac{TCD^{S} \times (IMP^{SR} + IMP^{RS})}{(TCD^{R} + TCD^{S})} \qquad (9)$$

It is possible that equation [7] will derive negative trade flow estimates. This is a contradiction of the trade relationship. However, it is possible because IMPLAN computes its commodity import estimates based on the RPCs calculated using the data for an area alone. As one aggregates areas (for example, combining two counties) the formula used to compute the RPCs tends to lower the aggregate areas dependence on locally produced goods and services. The result is that domestic imports are used more—so much more that sometimes $IMP^{\Sigma RS}$ for a particular commodity is larger than the sum of $IMP^{R}$ and $IMP^{S}$ for the same commodity. For the 238 counties used in the SEBAS SAM models there were 363,426 import evaluations (238 counties, 509 commodities, and 6 import evaluations per commodity). There were only 168 occasions where commodity imports for the aggregate area was greater than the sum of the commodity imports for the sub-regions (that is less than a 0.05 % import contradiction rate). When these negative events occurred the trade flow estimates were set to zero.

### 3.3 Balancing Interregional Trade Flows

Estimating the trade flows by either the location quotient or regional purchase coefficient methods still requires that the estimated flows be balanced so that they are consistent with the domestic exports and imports provided by IMPLAN. IMPLAN provides many SAM accounts for a single region model (see Figure 2). Two of these accounts provide IMPLAN estimates of purchases from other parts of the nation by local businesses and consumers. Two other accounts show exports to elsewhere in the country by local businesses and institutions. Aggregating these accounts to commodity totals provides the commodity imports and exports necessary to balance the interregional trade flows estimated by both the location quotient and regional purchases coefficients.

The SEBAS multiregional SAM models have a three-region geographical configuration. This means that the commodity domestic imports need to be parsed between the county, adjacent counties, counties in the remaining portion of the state, and the rest of the nation. Similarly, commodity domestic exports are parsed along the same spatial aggregates. Parsing domestic commodity imports and exports is accomplished using a modified RAS procedure (Figure 4).

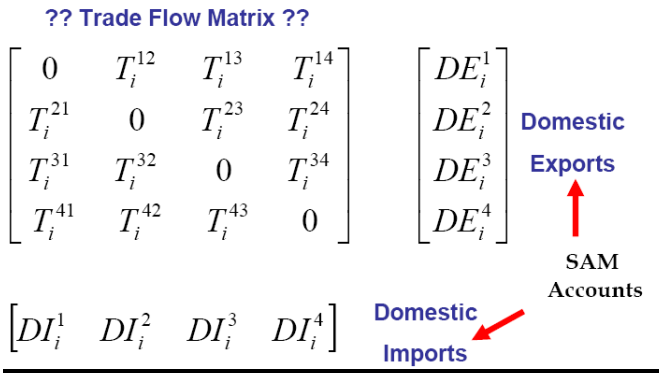



**Figure 4.** Interregional trade flow balancing framework (RAS procedure)

Local commodity consumption satisfied by local producers and foreign commodity imports and exports are assumed fixed and not subject to adjustment by the RAS balancing procedure. Local commodity consumption satisfied by local producers is equal to total commodity demand times the appropriate regional purchase coefficient. Foreign imports and exports by commodity are provided by IMPLAN.

## 4. Comparing SAM Multipliers

The multiregional SEBAS SAM models were compiled by endogenizing employee compensation, proprietors' income, and the nine household institutions shown in Table 2. As a result, two Leontief inverse matrices of direct, indirect, and induced effect multipliers were computed using either the location quotient derived trade flows or the regional purchase coefficient derived trade flows. The computational procedures used to compile the multiregional SAM models are described by Pyatt and Round (1985), Holland and Wyeth (1993), and Round (2003).

The interregional trade flow coefficients used to compile the SEBAS SAM models were estimated by the location quotient method. For the purpose of empirical comparisons, the location quotient method is assumed to be the benchmark. Similarly, the multiregional SAM multipliers calculated using the location quotient derived trade flows are also considered benchmark estimates in this paper. The multiplier matrix computed using the location quotient derived trade flows is identified as $M^{LQ}$ and the multiplier matrix compiled using the regional purchase coefficient derived trade flows is identified as $M^{RPC}$. Each of the multiplier matrices is square and contain186 rows and 186 columns. There are three regions—each having 51 producing sectors (Table 1), two factors, and nine household institutions (Table 2).

### 4.1 LQ vs RPC: Column Multipliers

The most fundamental measures of impact in a multiplier matrix are the total column multipliers or the column sums of the multiplier matrix elements. A column multiplier indicates the total impact on an economy (direct, indirect, and induced) of a one-dollar change in demand for the sector. In addition to the total impact, the column multipliers are decomposed into three partitions—one for the impact on the county, two for the impact on the adjacent counties, and three for the impact on the rest of the state (Figure 5).

| Impacted Region \ Regional Impact Source | County | Adjacent Counties | Rest of State |
|---|---|---|---|
| County | County on County | Adjacent Counties on County | Rest of State on County |
| Adjacent Counties | County on Adjacent Counties | Adjacent Counties on Adjacent Counties | Rest of State on Adjacent Counties |
| Rest of State | County on Rest of State | Adjacent Counties on Rest of State | Rest of State on Rest of State |
| ∑ | County Impact on State | Adjacent Counties Impact on State | Rest of State Impact on State |

**Figure 4**. Types of multiregional SAM (column) multipliers

Comparisons made between the multiplier matrices ($\boldsymbol{M}^{LQ}$ and $\boldsymbol{M}^{RPC}$) and presented in this paper are only in terms of the industrial sectors. The procedure used here to make the empirical comparisons is the "total percentage difference" (***TPD***) as described by Miller and Blair (1982),

$$TPD_j = 100 \times \frac{\sum_i m_{ij}^{RPC} - m_{ij}^{LQ}}{\sum_i m_{ij}^{LQ}}. \qquad (10)$$

$\boldsymbol{TPD}_j$ is the standardized total percentage difference for column $j$ and $m_{ij}^{RPC}$ and $m_{ij}^{LQ}$ are common elements of two multiplier matrices $\boldsymbol{M}^{RPC}$ and $\boldsymbol{M}^{LQ}$ being compared. In this case the multiplier matrix $\boldsymbol{M}^{LQ}$ is being used are a "frame of reference" or benchmark.

A graphical method is used to visually illustrate the variability that is generated by the two methods of estimating interregional trade flows due to the large number of pairs of multiplier matrices that are compared (238 pairs of multiregional SAM multiplier matrices). The graphical procedure used here is called a "box and whisker" diagram. The top of the box is the 3rd quartile estimate and the bottom of the box is the 1st quartile estimate (Tukey, 1977). The length of the box is based on the inter-quartile range of a distribution. The median is shown as a point within the box. The whiskers extending from the bottom and top of the box indicate range of the 1st and 4th quartiles of data.

The ***TPD***s of every total industrial column multiplier for all 238 multiregional SAM models were computed. Only the industrial sector rows and columns for the county region were evaluated using equation [10]. The box and whisker diagrams for the total industrial column multipliers are shown in Figure 6.

The top diagram presents the distribution of the county impact on the county column multipliers. Median county/county column multipliers derived using the LQ procedure appear to fall in the range of 1.2 to 1.4, while the maximum values ranging between 1.6 and 2.3. The bottom diagram shows the ***TPD***s for the total county/county column multipliers for the county region. The RPC county/county column multipliers are slightly smaller than LQ values (the median values are approximately 0.01 % lower). Similar graphical analyses for the county impacts on the adjacent counties, rest of the state, and the entire state are presented in Figures 7, 8, and 9. The RPC derived county/adjacent counties column multipliers are substantially lower than the LQ values (the median RPC values are approximately 20 % lower). However, the Median LQ county/adjacent counties column multipliers are only 0.1 to 0.2. The greatest variability in the column multiplier estimates are related to the county impacts on the rest of the state. Here, the median values of the RPC county/rest of state column multipliers can be as much as 150 % higher than the LQ median values, but the median LQ county/rest of state column multipliers are about 0.1.

In aggregate (i.e., in terms of the counties' impacts on the entire state, Figure 9), the LQ counties' total column multipliers have median values of a little over 1.5. Generally, the RPC method derives total county column multipliers that are, on average, higher than the LQ multipliers (approximately 1 to 3 % higher).

### 4.2 Final Demand Impact Analysis

In addition to the column multipliers, most impact analysts are interested in knowing what happens when the multipliers are used in an impact application. We evaluated the impacts that would be expected to occur in the event of a new industrial park. This industrial park is assumed to serve markets outside the state (either in the rest of the nation or overseas). The industrial park includes three types of firms; a household furniture and musical instruments manufacturer, a motor freight and warehousing operation, and a cable TV station. The business expenses per million dollars of operations for the entire industrial park are given in Table 4.

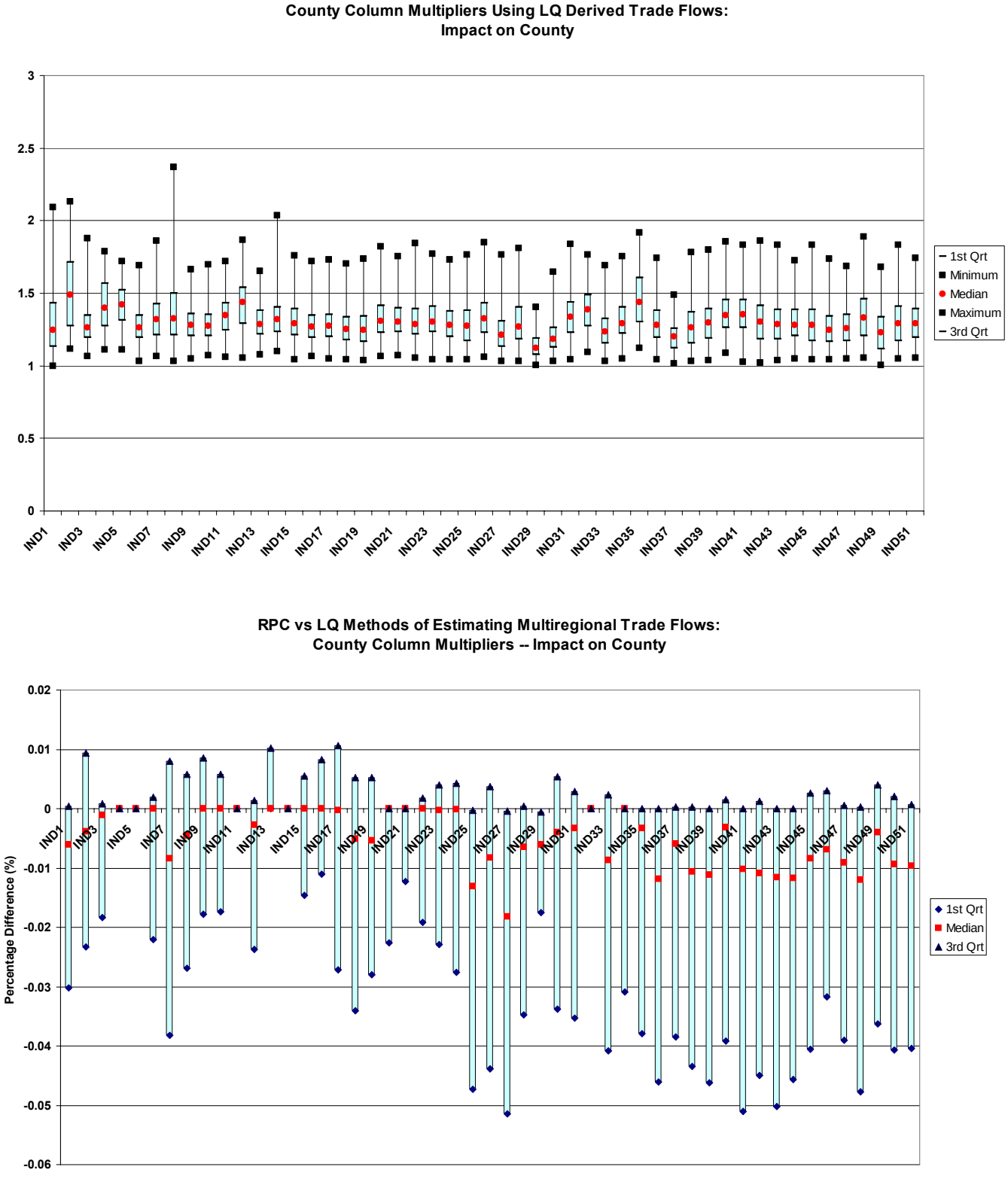



**Figure 6.** County/county column multiplier comparisons

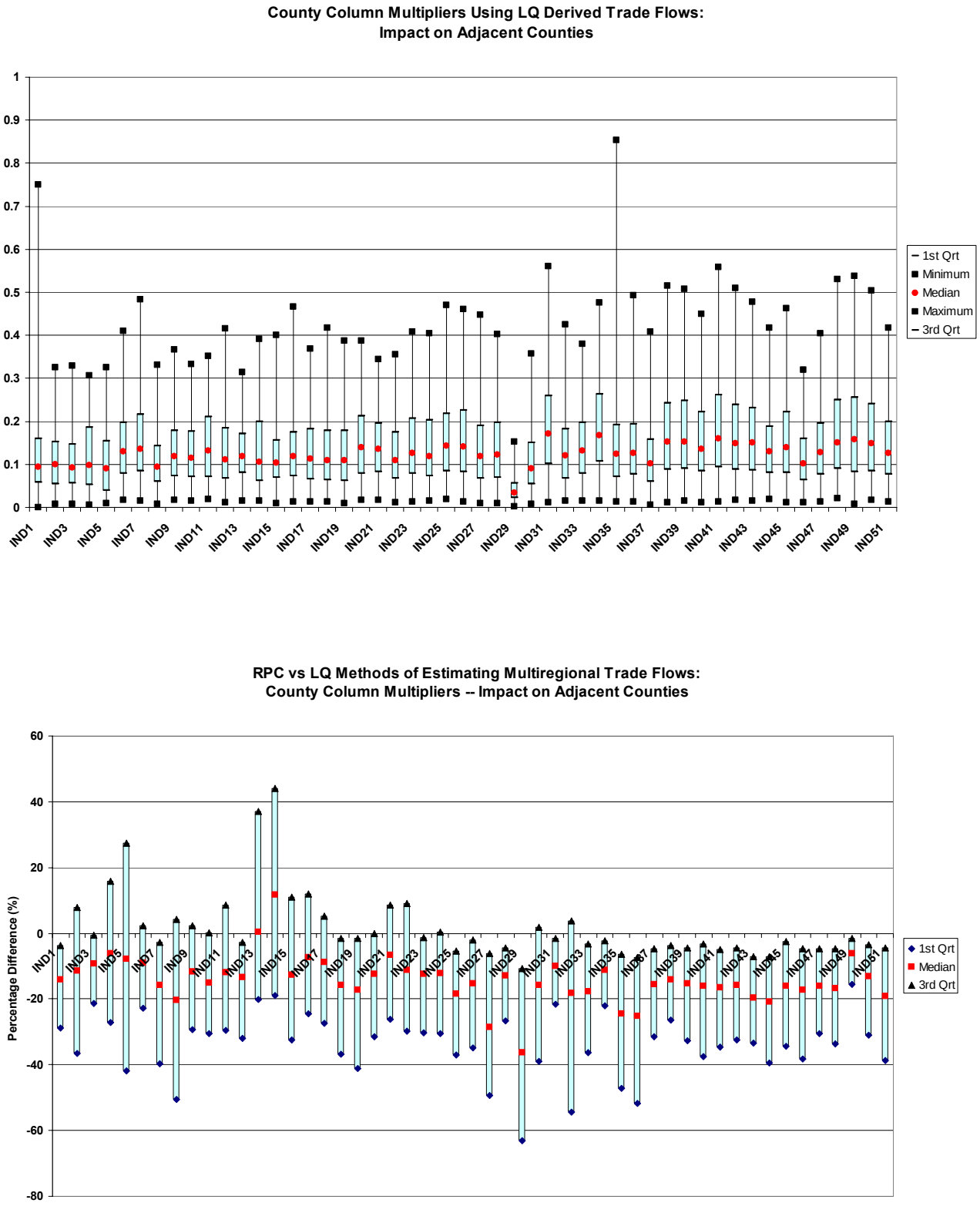



**Figure 7.** County/adjacent counties column multiplier comparison

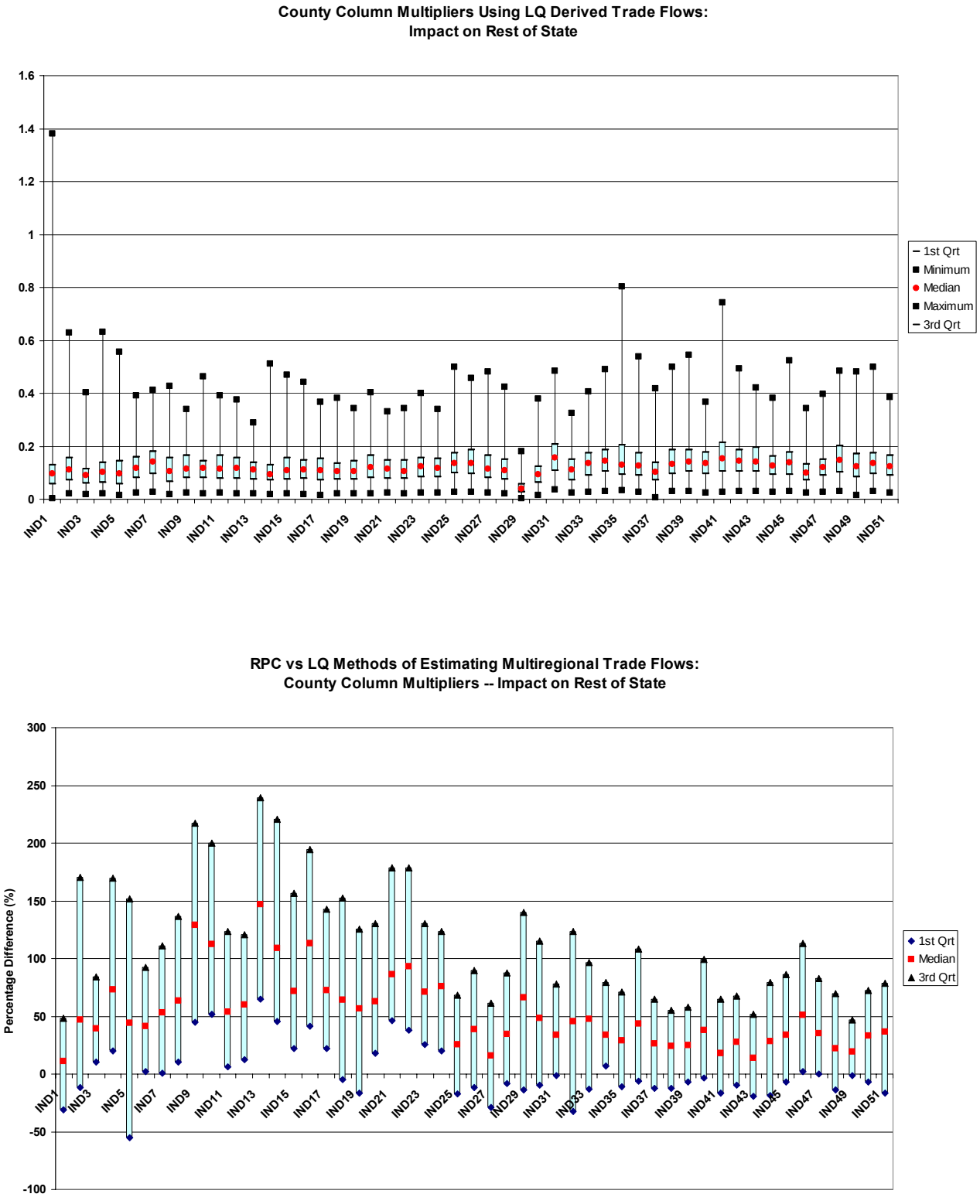



**Figure 8.** County/rest of state column multiplier comparison

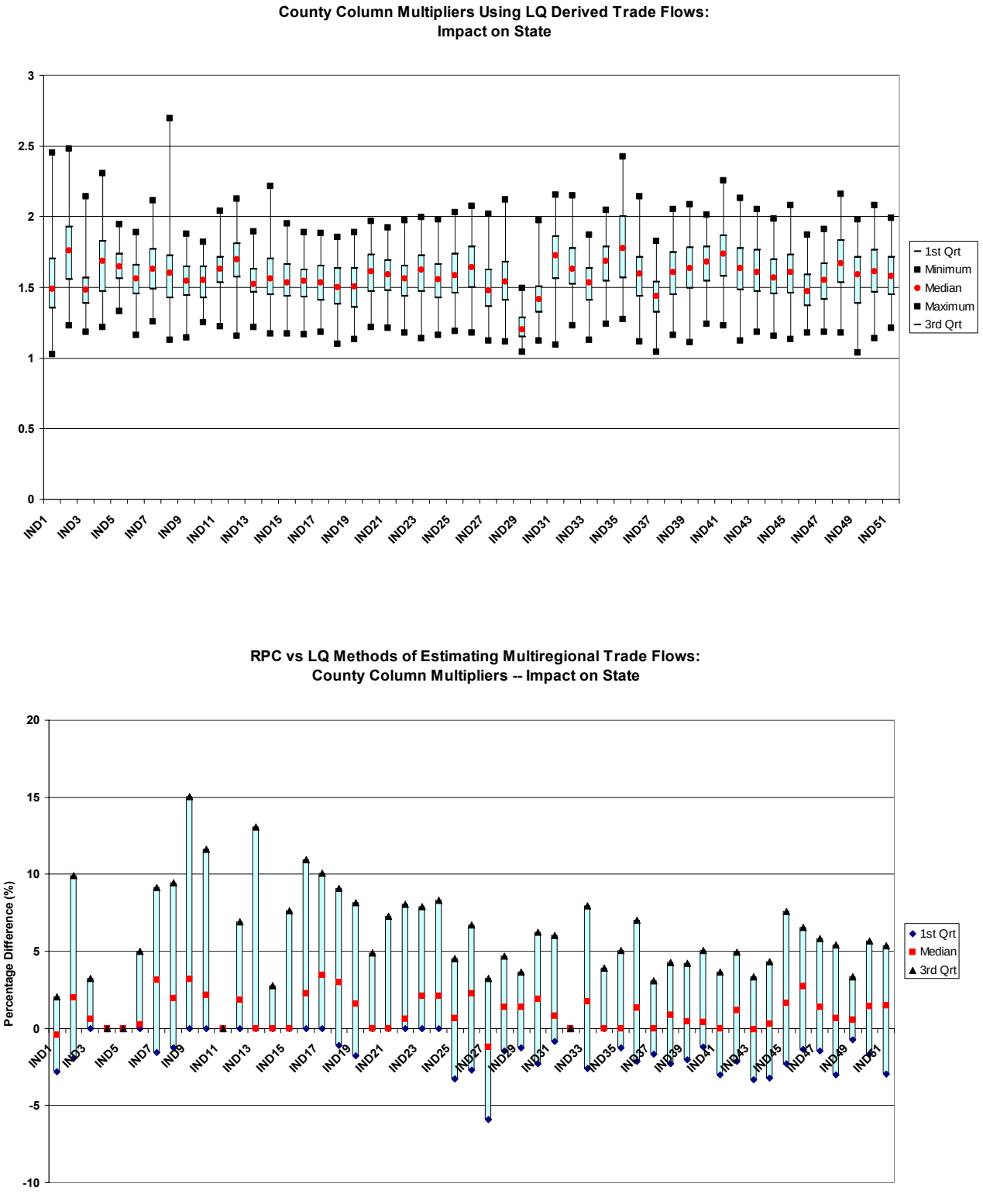



**Figure 9**. County/state total column multiplier comparison

Table 4. Industrial park business expenses per million dollars operation level

| | Expense Category | Expense |
|---|---|---|
| 1 | Crops | $33,168 |
| 2 | Livestock | $40 |
| 3 | Forestry and logging | $34,167 |
| 4 | Fishing, hunting and trapping | $43,493 |
| 5 | Petroleum and natural gas | $0 |
| 6 | Mined ores | $1 |
| 7 | Construction | $9,676 |
| 8 | Food, beverages and tobacco products | $0 |
| 9 | Textile products | $1,278 |
| 10 | Apparel | $21 |
| 11 | Leather and allied products | $24 |
| 12 | Wood products | $244,971 |
| 13 | Paper products | $67,529 |
| 14 | Refined petroleum and coal products | $0 |
| 15 | Chemical products | $0 |
| 16 | Plastics and rubber products | $62 |
| 17 | Mineral products | $1,426 |
| 18 | Metal products | $2,629 |
| 19 | Nonelectrical machinery and equipment | $5,925 |
| 20 | Computers and electronic components | $4,974 |
| 21 | Electircal appliances and equipment | $4,820 |
| 22 | Transportation equipment | $1,061 |
| 23 | Furniture and related products | $4,033 |
| 24 | Other manufactured goods | $4,247 |
| 25 | Wholesale and retail trade | $18,113 |
| 26 | Transportation | $114,954 |
| 27 | Finance | $50,515 |
| 28 | Insurance | $9,290 |
| 29 | Real estate | $6,117 |
| 30 | Utilities | $6,087 |
| 31 | Agriculture and forestry services | $6,523 |
| 32 | Mining services | $0 |
| 33 | Printing and publishing services | $499 |
| 34 | Internet and data process services | $4,909 |
| 35 | Motion picture and sound recording | $1,657 |
| 36 | Broadcasting | $4,622 |
| 37 | Rental and leasing services | $14,701 |
| 38 | Scientific and technical consulting services | $9,558 |
| 39 | Administrative and management support services | $13,851 |
| 40 | Waste management and remediation services | $10,894 |
| 41 | Educational services | $1,746 |
| 42 | Health care services | $406 |
| 43 | Recreation services | $650 |
| 44 | Hotels and other accomodations | $2,606 |
| 45 | Dining and drinking places | $3,608 |
| 46 | Repair and maintenance services | $13,993 |
| 47 | Personal and laundry services | $13,711 |
| 48 | Religious, grantmaking and similar organizations | $620 |
| 49 | Private households | $298 |
| 50 | Social assistance services | $0 |
| 51 | Post office | $1,551 |
| 52 | Labor compensation | $163,635 |
| 53 | Profits, dividends, rents, interest, etc | $45,781 |
| 54 | Business taxes | $15,562 |
| | Total Expenses | $1,000,000 |

*General Final Demand Impact Analysis*

We presume that the industrial park could be located in one of three places; in the county sub-region, in the adjacent counties sub-region, or in the rest of the state sub-region. We evaluated the impacts for these three possibilities. For each impact scenario examined, the business expenses were spatially distributed using both the location quotient derived interregional trade coefficients and the regional purchased coefficient derived interregional trade coefficients. The labor payments (employee compensation and proprietors' income) were spatially distributed using the 2000 sector-specific BEA "journey to work" commuting relationships. A 20 percent tax and savings factor was applied to the labor income.

The results of these adjustments determined the final demand vectors ($\Delta FD^{LQ}$ and $\Delta FD^{RPC}$) that were multiplied by the respective multiregional SAM multiplier matrices, i.e.,

$$\begin{aligned} \Delta Q^{LQ} &= M^{LQ} \times \Delta FD^{LQ} \quad \textbf{benchmark} \\ \Delta Q^{RPC} &= M^{RPC} \times \Delta FD^{RPC} \quad \textbf{alternative} \end{aligned} \tag{11}$$

Two vectors of impact results were derived for each of the regions (238 in all), one for a location quotient based impact analysis ($\Delta Q^{LQ}$) and one for a regional purchase coefficient based impact analysis ($\Delta Q^{RPC}$).

For comparative purposes, we computed the absolute percentage differences for the industrial portion of the impact vector representing the impact on the county, adjacent counties, and the rest of the state,

$$APD_{i,AB} = 100 \times \frac{|\Delta Q_{i,AB}^{RPC} - \Delta Q_{i,AB}^{LQ}|}{\Delta Q_{i,AB}^{LQ}}. \tag{12}$$ [5]

$APD_{i,AB}$ is the absolute percentage difference in the impacts on on the $i^{th}$ sector in sub-region $A$ (e.g., the county) due to the industrial park located in sub-region $B$ (e.g., the adjacent counties).[5] There will be nine sets of the industrial APD values for each impact analysis. The box diagrams for the three APDs for the industrial park located in the county sub-region are shown in Figure 4.[6] Those for the three APDs for the industrial park located in the county sub-region, the adjacent counties sub-region, and the rest of the state sub-region are shown in Figures 10, 11, and 12, respectively. In addition, each of figure shows the impacts on the county sub-region (top diagram), the adjacent sub-region (the middle diagram), and the rest of the state sub-region (the bottom diagram).

There is very little variation in the intra-regional impacts shown in Figure 10 (i.e., the impact on the county sub-region when the industrial park is also located in the county sub-region). The median APDs for the impacts due to industrial parks located in the county on the adjacent counties sub-region range between 0 and 20 percent. The median APDs for the impacts on the rest of the state sub-region due to an industrial park located in the county sub-region range between 20 and 100 percent. The variations of impacts for those cases where the industrial park is located in the adjacent counties sub-region are similar to the results above (Figure 11). That is there is little variation (i.e., as measured by the APDs) in the impact on the industrial sectors in the adjacent counties sub-region. The variation of the impacts on the industrial sectors of the county sub-region appears to fall within the range of 5 and 40 percent. A majority of the impacts on the industrial sectors located in the rest of the state sub-region again range between 20 and 100 percent, however, about one fourth are less than 20 percent.

Interestingly, the adjacent counties sub-region experiences the least variability in its industrial impacts due to the industrial park being located in the rest of the state region (Figure 12). Somewhat more variability in the industrial sector impacts is shown for the rest of the state sub-region. The greatest variability is shown for the impacts on the industrial sectors located in the county sub-region.

**Conditional Final Demand Impact Analysis**

The impact analyses demonstrated above allows both the multipliers and the final changes to the influenced by the trade coefficients that were used to compute the impacts. One might, how much of the variability of the impact analysis be due to the differences in the multipliers used or the final demand changes?

We examined this issue by carrying out three sets of impact analyses. The benchmark impact analyses were computed using the multiplier matrix and final demand change vector that were compiled using the location quotient derived trade coefficients. A second set of impact analyses used the location quotient derived final demand changes with the regional purchase coefficient derived multiplier matrix. The third set of impact analyses used the location quotient derived multiplier matrix with the regional purchase coefficient derived final demand vector. Specifically, we implemented the following impact scenarios,

[5] In both equation 12 and the text, adjacent counties were previously denoted as *R* and *S* (*A*=*R*, *B*=*S*)

[6] The whiskers have been dropped.

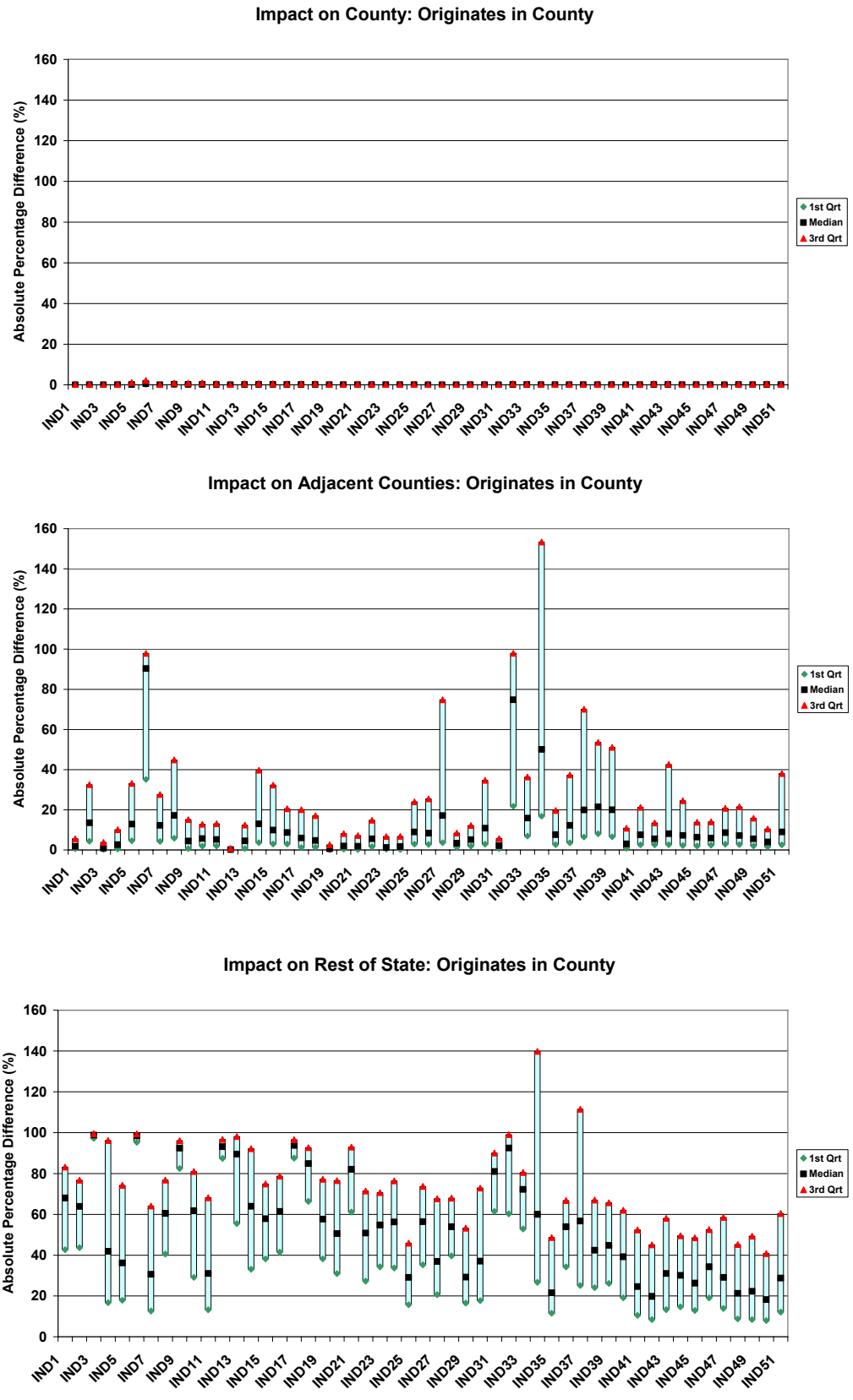



**Figure 10**. General final demand impacts originating in county

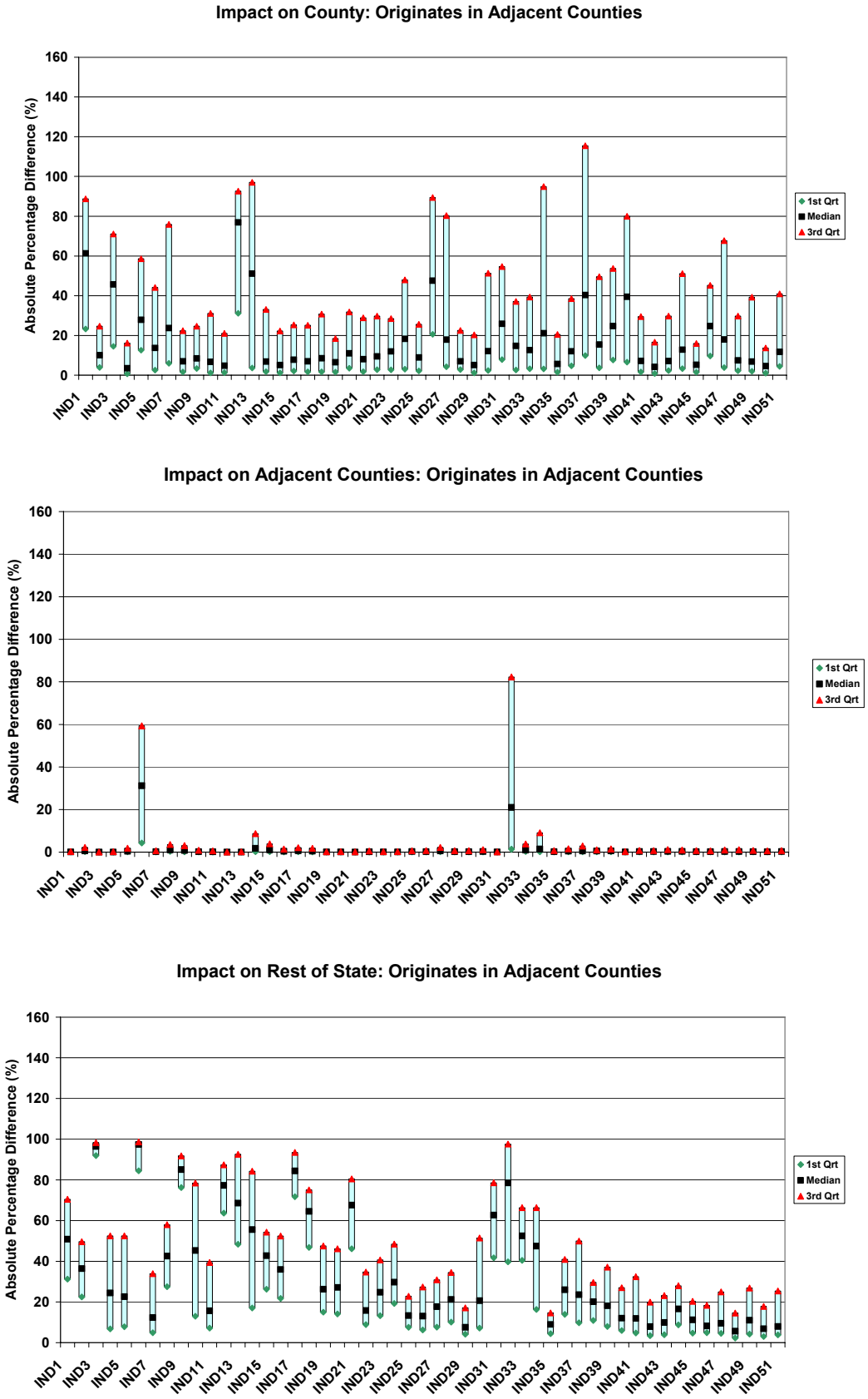



**Figure 11**. General final demand impacts originating in adjacent counties

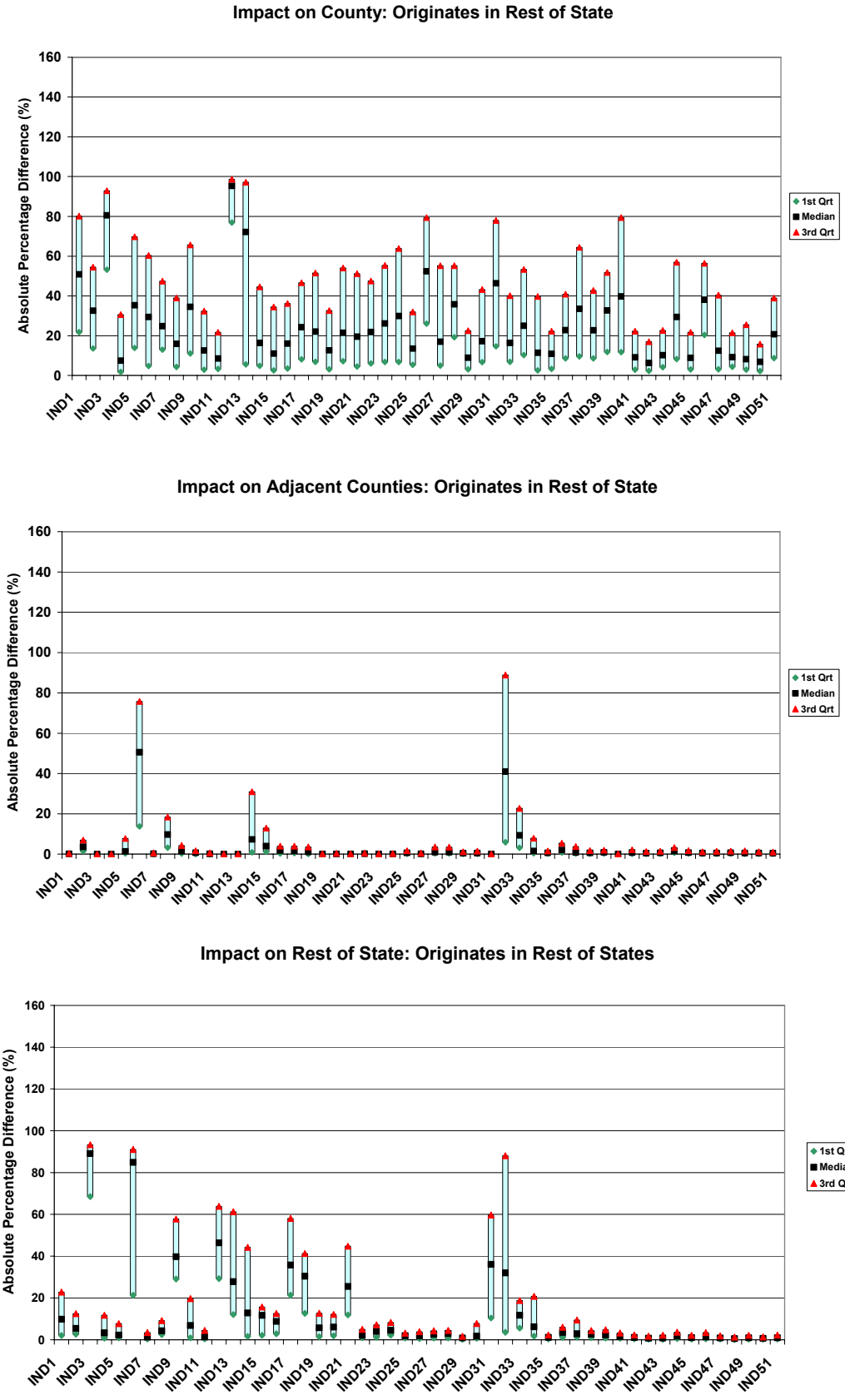



**Figure 12**. General final demand impacts originating in rest of the state

$$\Delta Q^{LQ} = M^{LQ} \times \Delta FD^{LQ} \quad \textbf{benchmark}$$

$$\Delta Q_0^{RPC} = M^{RPC} \times \Delta FD^{RPC} \quad \textbf{alternative 0}$$

$$\Delta Q_1^{RPC} = M^{RPC} \times \Delta FD^{LQ} \quad \textbf{alternative 1} \qquad (13)$$

$$\Delta Q_2^{RPC} = M^{LQ} \times \Delta FD^{RPC} \quad \textbf{alternative 2}$$

Three sets of ***STPD***s values for each of the 238 area SAM models were computed using the impact analyses in equation [13],

$$STPD_{A0} = 100 \times \frac{\sum_i |\Delta Q_{i,A0}^{RPC} - \Delta Q_{i,A}^{LQ}|}{\Delta Q_{i,A}^{LQ}} \quad \textbf{alternative 0}$$

$$STPD_{A1} = 100 \times \frac{\sum_i |\Delta Q_{i,A1}^{RPC} - \Delta Q_{i,A}^{LQ}|}{\Delta Q_{i,A}^{LQ}} \quad \textbf{alternative 1} \qquad (14)$$

$$STPD_{A2} = 100 \times \frac{\sum_i |\Delta Q_{i,A2}^{RPC} - \Delta Q_{i,A}^{LQ}|}{\Delta Q_{i,A}^{LQ}} \quad \textbf{alternative 2}$$

Comparing the benchmark and alternative 0 impact analyses provides the total variation in differences in impacts from both the multipliers and final demand. This represents the variability due to differences in the way that both the multipliers and final demand changes were estimated. Alternatives 1 and 2 provide a decomposition of the total variation. For example, if the benchmark and alternative 1 impact analyses are compared, we can see the effects of the multipliers on the impact analysis. Also, the effects on the impact analysis due to the final demand assumption are shown by comparing the benchmark and alternative 2 impact analyses.

Figure 13 shows the box diagrams for the ***STPD***s of the alternatives 0, 1, and 2. Comparing the box diagrams for ***STPD*** alternatives 1 and 2 clearly shows that most of the variability in the impact results is due to the affects of how the trade flows affected the multiplier estimates.

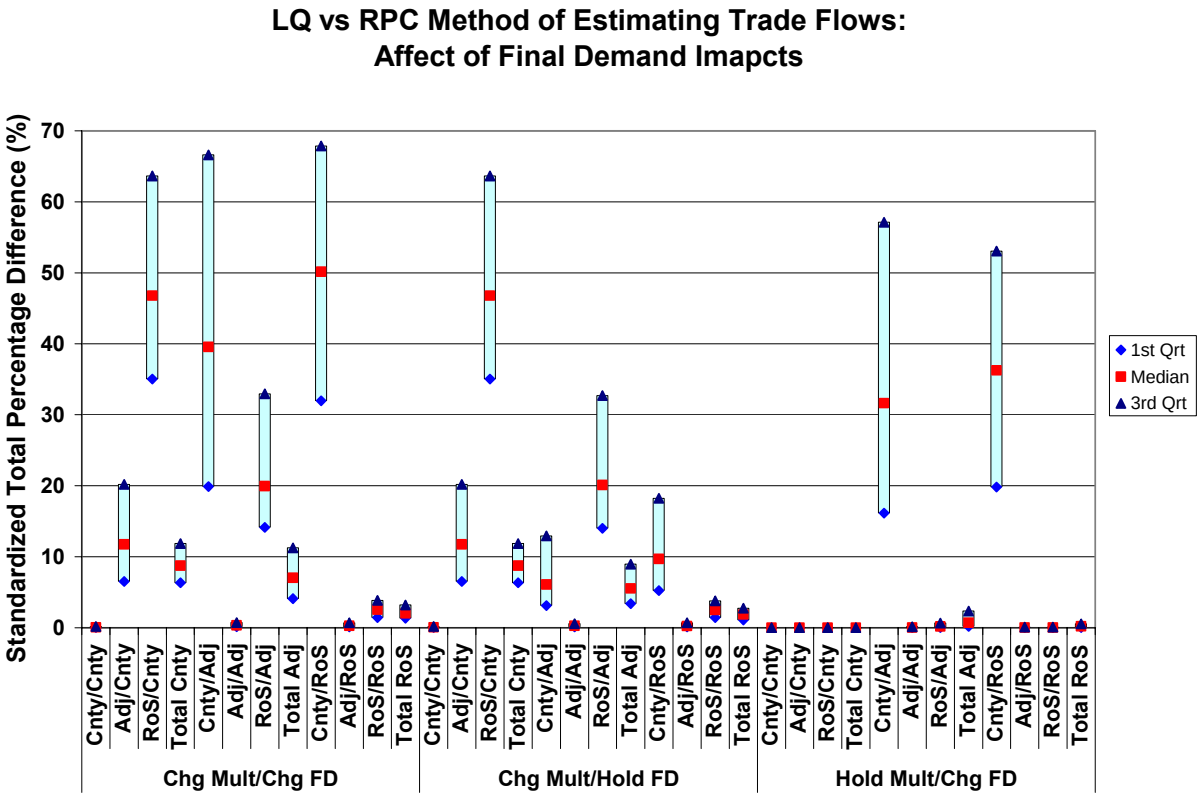



**Figure 13**. Variability of final demand impact estimates based on two techniques of deriving interregional commodity trade flows

## 5. Conclusion and Recommendations

SAM models provide regional economic development professionals with invaluable quantitative economic impact evaluation tools. These models permit assessments of different important policy decisions over an entire economic system using the effects of important economic aggregates and agents. IMPLAN provides social accounting data in a convenient format that can be used to construct single region input-output and SAM models. The availability of the Bureau of Transportation Statistics' Commodity Flow Survey (CFS) and BEA's "journey-to-work" commuter data are permitting economic impact modelers to extend IMPLAN's single regional SAM models to multiregional formats. Unfortunately, the Bureau of Transportation Statistics has not extended their CFS data to provide an official source for state-to-state commodity transport flows for public release and use. Jackson, et al (2004) describe methods of estimating trade flows using data from the commodity flow survey.

Little research exists concerning the creation of multiregional models at geographic scales lower than states, especially the roll that interregional trade plays. This paper evaluates the effects of using two interregional trade flow estimating procedures on multiregional SAM multipliers. One uses a variation of location quotient to estimate domestic exports. The other uses the regional purchase coefficients that IMPLAN produces to estimate domestic imports. The estimated domestic imports and exports for both sets of trade flow estimates are balanced to fit within IMPLAN's accounting framework. The techniques employed in this paper are applied to 238, 3-region multiregional SAM models.

The results presented in this paper clearly demonstrate that the methods used to estimate the interregional trade flows can substantially affect both the interregional multipliers and the estimated impacts that are derived from multiregional SAM models. These results should be quite perplexing to the regional economic impact practitioners because the trade flow matrices necessary to compile multiregional SAM models have to be estimated in some way. The purpose of this paper was simply to address the issue of how much difference the choice of estimating method makes.

Recently, inter-county trade flow estimates for each of the 509 commodities and services in the IMPLAN system have been constructed by Lindall et al. (2005). These estimates will make constructing multiregional SAM models feasible for almost any regional configuration a user may desire. One question is should the current regional purchase coefficients be the underlying accounting basis for the intraregional trade assumptions? Or, should the estimated trade flows provide not only the interregional trade assumptions between regions but also the intraregional trade assumptions?

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## References

Hewings, Geoffrey J.D.; Yasuhide Okuyama; and Michael Sonis. 2001. "Economic Interdependence within the Chicago Metropolitan Area: A Miyazawa Analysis." *Journal of Regional Science*, 41, pp. 195-217.

Holland, David and Peter Wyeth. 1993. "SAM Multipliers: Their Interpretation and Relationship to Input-Output Multipliers." Edited by Daniel M. Otto and Thomas G. Johnson in *Microcomputer-Based Input-Output Modeling: Applications to Economic Development*. Boulder, CO: Westview Press, pp. 181-197.

Isserman, Andrew. 1977. "The Location Quotient Approach to Estimating Regional Economic Impact." Journal of American Institute of Planners, January.

Jackson, Randall W. 2002. *Constructing US Interregional SAMs from IMPLAN Data: Issues and Methods.* 2002-14. Morgantown, WV: Regional Research Institute, West Virginia University.

Jackson, Randall W.; Walter R. Schwarm; Yasuide Okuyama; and Samia Islam. 2004. *A Method for Constructing Commodity by Industry Flow Matrices.* Research Paper 2004-5. Morgantown, WV: Regional Research Institute, West Virginia University.

Lindall, Scott; Olson, Doug; and Alward, Greg. 2005. Multiregional Models: The IMPLAN National Trade Flows Model. Prepared for the 2005 MCRSA/SRSA Meetings in Arlington VA April 7-9.

King, Benjamin B. 1985. "What is a SAM?" Edited by Graham Pyatt and Jefferey I. Round in *Social Accounting Matrices: A Basis for Planning*. Washington, DC: The World Bank, 17-51.

Miller, Ronald E. and Peter D. Blair. 1982. *State-Level Technology in the U.S. Multiregional Input-Output Model*. Working Papers in Regional Science and Transportation, No. 65. Philadelphia, PA: University of Pennsylvania.

Minnesota IMPLAN Group (MIG), Inc. 1998. *Elements of the Social Accounting Matrix*. MIG IMPLAN Technical Report TR-98002. Stillwater, MN: Minnesota IMPLAN Group, Inc.

Minnesota IMPLAN Group, Inc. (MIG). 2000. *IMPLAN Professional, Version 2.0: Social Accounting & Impact Analysis Software, 2nd Edition*. Stillwater, MN: Minnesota IMPLAN Group, Inc. (June).

Peterson, William C. and Roger J. Beck. 2001. "Central Places, Trade Flows, and Input-Output Analysis: Another Look at Estimating Regional Purchase Coefficients." Paper presented at the annual meeting of the Southern Regional Science Association on April 5-7 in Asutin, TX.

Pyatt, Graham and Jefferey I. Round. 1985. "Regional Accounts in a SAM Framework." Edited by Graham Pyatt and Jefferey I. Round in *Social Accounting Matrices: A Basis for Planning*. Washington, DC: The World Bank, pp. 84-95.

Robinson, Dennis P. and Thomas G. Johnson. 2005. *A User Guide to the Socio-Economic Benefits Assessment System: A Rural Business-Cooperative Services Assessment Tool for Economic Development*. Columbia, MO: Community Policy Analysis Center (CPAC), University of Missouri-Columbia (January).

Round, Jeffery. 2003. "Social Accounting Matrices and SAM-Based Multiplier Analysis. Edited by Francois Bourguignon and Luiz A. Pereira da Silva in *Evaluating the Poverty and Distributional Impact of Economic Policies (Techniques and Tools)*. Washington, DC: The World Bank, in draft (March).

Southworth, Frank and Bruce E. Peterson. 2000. "Intermodal and International Freight Network Modeling." *Transportation Research Part C*, 8, pp. 147-166.

Tukey, John W. 1977. *Exploratory Data Analysis, First Edition*. Reading, MA: Addison-Wesley Publishing Co.