Estimation of State-by-State Trade Flows for Service Industries*

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Abstract. Multiregional input-output models have been discussed for many years, but their implementation has been rare. The limitations are mostly because of the difficulty of adding spatial detail representing trade flows between the 50 states. Since 1993, however, Commodity Flow Survey (CFS) data have been widely used, but these data have several inherent problems. The most serious ones are that the CFS does not report trade flows below the state level and also they are not the complete trade flows even between the states. To construct trade flows as the basic data set for a U.S. interstate MRIO, there have recently been various attempts to estimate interregional trade flows based on the 1997 CFS. However, the common problem with the all of these trials is that there has been too little attention paid to the problems of estimating trade flows among the service sectors. In the modern information economy, this is a serious omission. Therefore, this research addresses new approaches to relaxing the assumption of no interstate trade in services and, instead, proposes estimates of interstate trade flows for the service sectorss. Using Geographically Weighted Regressions (GWR) econometric analysis, this study proposes and implements a sequence of computational and spatial econometric steps for estimating inter-state trade flows for the major service sectors required for implementing a U.S. interstate MRIO model. Furthermore, the approach can be expanded to examine the economic relationships between sub-state level areas, as well as to forecast future trade flows.

JEL Classification: C31, R12, R15, L8, L9

Key words: Service trades, geographically weighted regressions, multi-regional input-output

1 Introduction and Issues

National economic models of the U.S. aggregate over large numbers of diverse regions. However, many regional scientists are interested in evaluating socioeconomic impacts that involve the states, especially in terms of their policy significance. A U.S. Multi-regional input-output model is an example of useful spatial disaggregation, but models like this are still difficult to construct because of the difficulty of developing detailed state-by-state trade data (Lahr, 1993).

The U.S. Commodity Transportation Survey data on interregional trade flows have been available since 1977, but reporting was discontinued for some years. For the years since 1993, this data deficit can be met to some extent with the recent Commodity Flow Survey (CFS) data from the Bureau of Transportation Statistics (BTS). Since 1993, CFS data have been widely used, but the data have several inherent problems (Erlbaum and Holguin-Veras, 2005). The most serious one among them is that the CFS data do not include trade flows below the state level but also that they are not complete even between the states. Since Polenske (1980) and Faucett Associates (1983), there has been no comprehensive inventory of flows for probably these reasons.

Furthermore, even though the commodity flow data between the states of the U.S. are published every five years, there is no inventory of trade flows for services. Recent approaches to estimating state-by-state trade flows of U.S. based on 1997 CFS, therefore, have included too little attention paid to the problems of estimating the trade flows among service sectors and maintained strong assumptions of no or small trades in these sectors. However, in the modern information economy, this is a serious omission.

Therefore, this research addresses new approaches to relaxing these assumptions and, instead, proposes estimates of interstate trade flows for the service sectors. Using Geographically Weighted Regressions (GWR) econometric analysis, this study proposes and implements a sequence of computational and spatial econometric steps for estimating inter-state trade flows among all of the major service sectors, especially as required for implementing a U.S. interstate MRIO model. Furthermore, the approach can be expanded to examine the economic relationships between sub-state-level areas, as well as to forecast future trade flows.

The next section of this paper develops the background for estimating state-by-state trade flows. In the following section, based on specially prepared data, the Geographically Weighted Regressions (GWR) econometric methodology and an application is explained. In the final section, conclusions and some remarks are elaborated.

2 Trade Flows Estimation and Service Industries

The existence of many unreported values in trade flow data has required relying on other data sources for completeness. Harrigan et al (1981) compared several old methodologies for estimating interregional trade flows and showed 'more information, better results', based on 1973 Scotland data. This is because all techniques used as examples are simple ratio-based methodologies. Using the CFS, based on an approach of location quotients, Lie and Vilain (2004) estimated trade inflows of subregional levels below the states. However, this requires very restrictive assumptions, resulting in sizable errors in the estimates.

More recently, in order to construct trade flows as the basic data set for an MRIO, there have been some attempts to estimate interregional trade flows. Using data from the 1997 Commodity Flow Survey (CFS), Jackson et al. (2006) combined IMPLAN data to adjust incomplete CFS information using an error-minimizing equation via Box-Cox transformation regressions and double-log regressions. Another attempt included a doubly-constrained gravity model based on the Oak Ridge National Labs (ORNL) data for county-to-county distances by mode of transportation, CFS for ton-miles by sector, and IMPLAN data for total supply and demand by county (Lindall et al, 2005). The CFS data used for a criterion index, whether the average of the estimated ton-miles is matched to the CFS ton-miles or not. Generally, doubly-constrained gravity models reflect interactive effects of trades, but not only to allocate the exports to regions. The model basically accepts the fact that attractiveness of an economy is proportional to the trade flows, but distances between two regions are inversely proportional. Different from these studies, Canning and Wang (2005) developed a new approach estimating interregional trade flows basically based on the techniques developed by Wilson (1970) and Batten (1982), and tested the performance using Global Trade Analysis Project (GTAP) data. Park et al. (2007) used the same basic data sources as Jackson et al. (2006) and Lindall et al (2005), but adopted a different estimation approach relying on an AFM (adjusted flow model) and a DFM (doubly-constrained Fratar model). This two-step approach allows the incomplete CFS to be completed with the AFM and updated with the DFM.

However, the common problem in these all trials is that there has not been a way to fully estimate the trade flows for service sectors. Only average coefficients of commodity sectors (Jackson et al, 2006) or high (but not specified in the study) exponents for the distance functions were used for the estimation of service industries, excluding trade flows over long distances (Lindall et al, 2005). Or strong assumption of no service trade flows, mainly due to the implausibility of estimates was applied (Park et al. 2007).

However, the problem should be addressed by estimating state-by-state or sub-state level flows for the service industries. Unfortunately, the problem residing in the all studies results partly from an applicable methodology to estimate the amount or partly from inexistence of appropriate data to apply the regional economic models available currently. To conduct a survey to verify, at least, the state-level trade flows of service industries requires huge cost, although it has been perceived importantly, especially due to the characteristic of information society. Good news is that we have total imports and exports obtained from the widely used IMPLAN data and an appropriate methodology which is never applied.

The following basic processing steps involve building a database from Park et al (2007), developing the new approach of this study and relaxing the assumption of no interstate trade in services and, instead, estimating interstate trade flows for all the major service sectors of the USC-sector system (29 commodity sectors and 18 service sectors as shown in Table A1 in the Appendix). The latter is easily converted to many other sector systems and introduced in the next section.

Table 1. Definition of Variables, 2000

Variables			Description	Note
Dependent		USC service sectors (USC30 to USC47)	Refer to Table A1 in Appendices	The GWR is regressed for each USC sector, tally 18 times.
Independent	Core variables set*	Agg_usc01	Refer to Table A1 in Appendices	
		Agg_usc02		
		Agg_usc03		
		Agg_usc04		
		Agg_usc05		
		Agg_usc06		
		Agg_usc07		
		Agg_usc08		
		Agg_usc09		
		mean_agg	Average of Agg_usc sectors	(sum of agg_usc i)/(sum of number of i)
	Common Variables set**	Pop	Population of each state	Unit: 1000
		Den	Population/state size	Unit: 1000/square miles
		Pop_cha	Percent of population change between 1990 and 2000	Unit: %, 100*{=(2000-1990)/1990}
		I_ac	Aged-child index	Aged=over or at 65, Child=under 18
		I_dep	Dependency index	100*(under18 + over65)/(between1865)
		P_n_wh	Percent of non-white residents	
		P_t_imm	Percent of total immigrants	
		P_oth_st	Percent of population born at other areas	
		M_temp	Average temperature	Fahrenheit
		R_crime	Crime rates per 1000 population	(Violent+Property)/pop
		I_econdep	Percent of economic dependency	100*(number of unemployed)/(number of employed)
		P_belowpov	Percent of below poverty status during last one year	
		HR_index	Homeowner and Renter Index	US Index=200: Recalculate owner occupied house prices and rent payments to be indexed
		G_st_tax	General states tax	Unit: cents per dollar
		I_livcost	Living cost index	US index=100: (hostpital cost)+(energy expenditures)+(gasoline prices)
		Disp_inc	Disposable income per capita	Unit: $1000
		Gov_exp	Government expenditure	Unit: $Billions
		GSPi	Gross state products for USC sector i	Unit: $Millions, i=30 to 47
	Specific variables set***	N_pub_12	Number of public enrollment under 12	Unit: 1000, USC42
		N_pub_high	Number of public enrollment higher education	Unit: 1000, USC42
		Tax_gas	Tax for Gas	Unit: cents/gallon, USC30-35
		I_Ener_exp	Energy expenditure index	US=100, USC30-35
		Rev_tele	Revenue from telecommunication	Unit: $Millions,USC36
		Spn_dtrav	Expenditure of domestic_travel	Unit:$M., 2001, USC45

Note: All variables are based on year 2000, except one variable, Spn_dtrav.

* All core variables are used for the GWR regression, and the unit for all variables is $million.

** Some independent variables in common variables set are selected for the GWR regressions

*** Specific variables set is only for specified sector shown in Note

3 Data and Model

Data sources for this study are various. Dependent variable for each USC service sectors are selected from 2001 IMPLAN domestic imports and the values are shown at Table A2. The IMPLAN data support estimates of five kinds of economic transactions: total commodity output, domestic/foreign import/export. From the data, intra-state flows within each state are calculated, which can be converted to a diagonal state-by-state matrix ($\hat{\mathbf{T}}$) in order to be added to the fitted non-diagonal trade flows ($\mathbf{T}^*$).

See Table A3 for the fixed intra-state flow of service sectors for $\hat{\mathbf{T}}$, where the intra-state flows are adjusted by including foreign imports. This is because the foreign imports which are not consumed in the local area but transported to other state(s) are excluded from the state- or county-level IMPLAN data (Park et al., 2007; Giuliano et al., 2006). Refer to Table 1 for the definition of each variable. To estimate the dependent variable for estimation of the various USC service sector trade flows, basic independent variables are drawn from the *State and Metropolitan Area Data Book* (http://www.census.gov/compendia/smadb/) and *County Business Patterns* (http://censtats.census.gov/cbpnaic/cbpnaic.shtml) for 2000.

Table 1 shows which independent variables are selected for each dependent (service) variable, where all independent variables are classified into three categories. Core variables used for the GWR regression include USC commodity sectors, aggregated to nine sectors corresponding to the aggregation sector in the CFS. This is to examine the effects of physical commodity sectors on service sectors. To compare individual effects of commodity sectors and overall effect of all commodities, average values of commodity sectors are added. This separation reveals whether or not it is acceptable to use average parameters obtained from commodity sectors for the estimation of service trade flows. From independent variables in common variables set, some variables are selected for the GWR regressions, according to the expected relation with each dependent industry. Specific variables set is only for specified sector noted in the last column of Table 1. All variables are based on year 2000, except one variable of expenditure of domestic travel (Spn_dtrav), because of the limitation to obtain the data for 2000.

There is only limited information available on interstate trade in services. In general, the gravity model is widely used to estimate trade flows, because it reflects spatial effects. Indeed, territorial location is important for trading, and gravity models reflect most importantly inherent distance. However, the possibly overused log-transformed gravity model is based on ordinary least squares (OLS), and hence ignores ‘spatial dependency’ and ‘heteroscadasticity’ resulting from many inherent invisible characteristics of each region (Anselin, 1980; 1988; LeSage 1999). Therefore, an econometric approach to reflecting spatial effects is critical when estimating trade flows (Porojan, 2001; LeSage and Pace, 2006).

However, direct use of revised gravity model based on spatial autoregressive models (e.g. SAR, SEM, or SAC) cannot deliver the direct estimates of trade flows, but fix only parameters. Still, in those approaches, the distance is critical. However, for service sectors, other socioeconomic factors are more important due to special characteristics. To directly estimate trade flows of service sectors between states, therefore, it is important to consider other socioeconomic and environmental effects as well as distance effects simultaneously. The Geographically Weighted Regressions (GWR) econometric model (Brunsdon et al, 1996) can be applied to this approach. However, Locally linear regression model by McMillen (1996) is not appropriate in the estimation of trade flows for service sectors because it only reflects distances between states, although the approach is widely used as a GWR approach.

The GWR model can be rewritten according to LeSage (1999, p.205~206) as applying Weighted Least Squares (WLS). If ε_i has heteroscadasticity according to spatial (i) characteristics, a new variance matrix of error term ε_i can be specified as follows.

$$\sigma_\varepsilon^2 = \begin{bmatrix} \sigma_1^2 & 0 & \cdots & 0 \\ 0 & \sigma_2^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_n^2 \end{bmatrix} \qquad (1)$$

Therefore, net domestic import of service sector vector y_i can be weighted by σ_ε^2 letting error term ε_i follow normal distributions.

$$y_i = \sum_{k=1}^{K} \beta_k x_i + \varepsilon_i \qquad (2)$$

$$\frac{y_i}{\sigma_i} = \frac{1}{\sigma_i}\sum_{k=1}^{K}\beta_k x_i + \frac{\varepsilon_i}{\sigma_i} \qquad \frac{\varepsilon_i}{\sigma_i} \sim N(0, I) \tag{3}$$

If W_i is a similar weight to adjust a regional heteroscadasticity, then equation (3) can be shown as,

$$\sqrt{W_i}\, y = \sqrt{W_i}\, X\beta_i + \sqrt{W_i}\,\varepsilon_i \tag{4}$$

where, an i is spatial observation (e.g. state, county, etc.) and β_i is K x 1 parameter column vector related to region i. W_i represents n x n diagonal matrix including distance-based weights for i and hence reflects the distance between i and all other regions, d_i.

Here, distance-based weights can be suggested via three types. First, Brunsdon et al. (1996) introduce "bandwidth" decay parameter θ shown in equations (5) and (7), where different θs will produce different exponential decay results varying over regions.

$$W_i^B = \sqrt{\exp(-d_i / \theta)} \tag{5}$$

The second set of weights were developed by McMillen (1996) using a tri-cube function, where q_i indicates the distance of the q^{th} nearest neighbor to region i. This weights the relationship between regions one more using d_i and q_i.

$$W_i^M = \begin{cases} (1-(d_i / q_i)^3)^3, & if \quad d_i < q_i \\ 0 & otherwise \end{cases} \tag{6}$$

Finally, the Gaussian standard normal density function can be applied to W_i, where σ indicates the standard deviation of the distance vector d_i.

$$W_i^G = \phi(d_i / \sigma\theta) \tag{7}$$

The “bandwidth” decay parameter θ relies on cross-validation value that uses a score function shown in equation (8) and indicator q_i can be computed as shown in equation (6). However, because the indicator q_i in tri-cube function of equation (6) only depends distances, it is not useful in this study. Hence, to estimate the optimal decay parameter θ, new iteration approach was used as,

$$\sum_{i=1}^{n}(y_i - y^*_{\neq i}(\theta))^2 \tag{8}$$

where, $y^*_{\neq i}$ is the optimally fitted value of y_i omitting region i.

The equation (8), therefore, shows that the θ is selected when sum of residual is minimized using the similar weighted least squares in equation (4) via iterations. In other words, the most optimally estimated $y^*_{\neq i}$ reflects all effects of the independent variables and invisible spatial relations given at a fixed distance. Therefore, the weights W_i^{λ} ($\lambda = B$ or G) are not fixed as other spatial autoregressive models are, but flexibly changed, depending on the independent variables. This study used the GWR approach based on “bandwidth” decay parameter θ to adjust the distance-effects with various independent variables.

Because the optimal “bandwidth”, $\hat{\theta}$, is selected from the equation (8) omitting regressed region i itself, I separate the trade matrix T into two types. One is the diagonal matrix of intra-state trade movement by each state, denoted as $\hat{T}$. Another is non-diagonal trade flow ($\tilde{T}$) empty in the main diagonal. The existing data set includes only total domestic imports without the non-diagonal state-by-state trade flows $\tilde{T}$. Therefore, given $\hat{T}$, the $\tilde{T}$ is estimated using the GWR. Based on the prediction vector y_i^h for each service sector after being estimated optimally based on the $\hat{\theta}$ from the equation (4), the estimated trade flows $\tilde{T}^*$ of $\tilde{T}$ is calibrated,

$$\tilde{T}^*{}_s = (W_i^{*\,R\Sigma}\hat{W}_i^{-1}\hat{y}_i^h)_s \tag{9}$$

where, W_i^* is the fitted weighted matrix, ${}^{R\Sigma}\hat{W}_i^{-1}$ is inverse matrix of ${}^{R\Sigma}\hat{W}_i$ where ${}^{R\Sigma}\hat{W}_i$ is diagonal matrix of row sum of W_i^*, $\hat{y}_i^h$ is diagonal matrix of y_i^h, and s indicates each service sector (s =USC Sector 30 to USC Sector 47).

Finally, the estimated trade flows are obtained from the equation (10).

$$T_s^* = \tilde{T}_s^* + \hat{T}_s \tag{10}$$

An application is shown in the next section for s =USC Sector 42, education services industry.

4 An Application: Case of Education Service

As described in the previous section, in the case exploiting data on the sectors without trade flow data but with only domestic outflows or inflows data, limited applications to estimate trade flows have been implemented. For the estimation of service sectors, I applied the GWR methodology with the W_i^G bandwidth for USC Sector 42, education service sector. Another application using W_i^B bandwidth doesn't show better estimates than the application of the W_i^G bandwidth for all cases. From Table 1, the selected variables are described in Table 2.

The GWR approach yields different coefficient results by each state and hence each state can have its own fixed coefficients. To understand the effects of commodity sectors, two regressed results are shown in Table 3 and 4. While Table 3 only has average domestic import of all 29 commodities as an independent variable, Table 4 shows 9 types of aggregate USC commodity sectors, corresponding to the classification of the CFS. From adjusted R-squares in both tables, we can verify that the GWR results explain more than those of OLS.

The estimated results of coefficients show factors such as population size (Pop), disposable income per capita (Disp_inc), related to education consumption induce increase of consumption of education service from other states. While general government expenditures

(Gov_exp) increase imports of education services, more Gross State Product of education services in each state (GSP_USC Sector 42) decrease the imports. Also, higher education (N_pub_high) induces more imports, but complementary education (N_pub_12) relies upon each individual state. Finally, worse socioeconomic environments (R_crime and HR_index) reduce the imports of education services.

Table 2. Selected Variables for the GWR: USC Sector 42, Education Service

Variables			Mean	Standard Deviation
Dependent		USC42	791	1144
Independent	Core variables set	Agg_usc01	3272	3321
		Agg_usc02	5284	5298
		Agg_usc03	438	428
		Agg_usc04	4718	5014
		Agg_usc05	4469	4184
		Agg_usc06	7477	7924
		Agg_usc07	9626	9734
		Agg_usc08	12011	13118
		Agg_usc09	5925	6100
		mean_agg	5913	5979
	Common Variables set	Pop	5518	6164
		M_temp	53	9
		R_crime	41	10
		HR_index	229	14
		Disp_inc	21	26
		Gov_exp	25	3
		GSP_USC42	926	1080
	Specific variables set	N_pub_12	300	367
		N_pub_high	1554	2121

Note: The independent variable of mean_agg is used instead of the 9 types of aggregated USC sectors to verify the effects by commodity type. Those results are shown in Table 3 and 4, respectively.

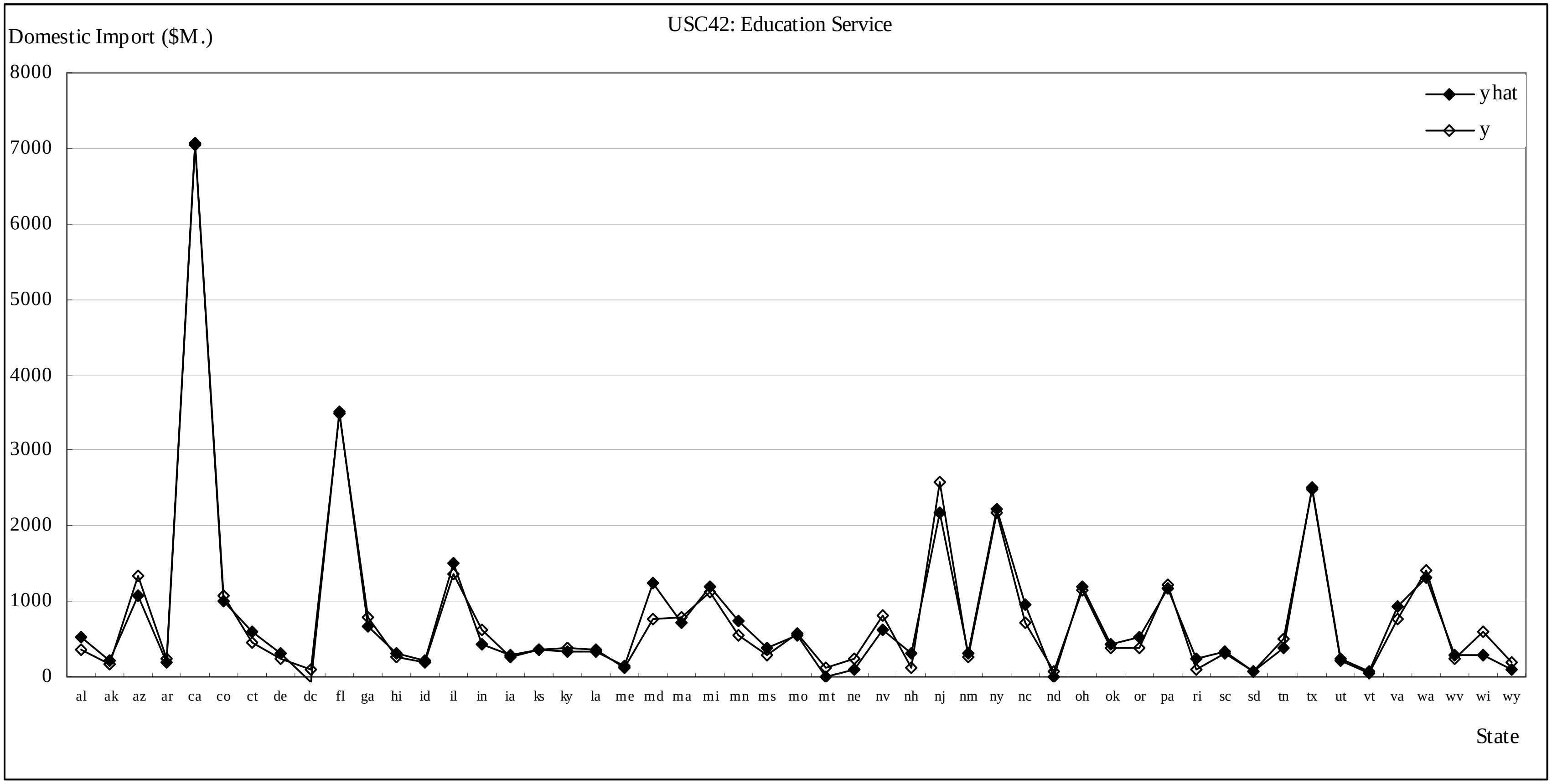
Table 3. Results of Geographically Weighted Regression: Case of mean_agg

	Intercept	mean_agg	Pop	M_temp	R_crime	HR_index	Disp_inc	Gov_exp	N_pub_12	N_pub_ high	GSP_US C42	R_sq	Adj_R_sq	Bandwidth	DW	N
GWR																
al	1150.17	-0.2496 ***	0.5523 ***	12.9856	-9.4452 *	-11.8662 **	9.1019	56.7000 ***	-1.3386 ***	2.1068 ***	-0.3272 ***	0.9636	0.9546	1.2469		51
ak	-2306.24 *	-0.1319 ***	0.3309 *	6.0023	-1.8352	1.2458	17.0324	76.4152 ***	-1.2723 **	3.7760 ***	-0.4155 ***					
az	-144.20	-0.2681 ***	0.5319 ***	6.5346	-3.5243	-6.9871 *	18.3912 **	70.0723 ***	-1.3914 ***	2.6544 ***	-0.3923 ***					
ar	963.21	-0.2596 ***	0.5525 ***	11.3061	-8.4431 *	-10.9313 **	10.9697	58.2389 ***	-1.3454 ***	2.2295 ***	-0.3390 ***					
ca	-653.07	-0.2522 ***	0.5126 ***	4.7965	-2.3022	-4.9825	18.9991 **	73.0609 ***	-1.4074 ***	2.8038 ***	-0.4004 ***					
co	176.92	-0.2692 ***	0.5309 ***	8.3196	-4.9340	-8.1594 *	17.3680 **	66.4490 ***	-1.3465 ***	2.5345 ***	-0.3770 ***					
ct	1304.42	-0.2302 ***	0.5367 ***	15.5556 *	-10.4539 **	-12.8597 **	7.4765	54.8795 ***	-1.2888 ***	1.9284 **	-0.3122 ***					
de	1283.96	-0.2333 ***	0.5392 ***	15.1821 *	-10.3109 **	-12.7279 **	7.7203	55.1926 ***	-1.2990 ***	1.9684 **	-0.3148 ***					
dc	1270.43	-0.2344 ***	0.5394 ***	15.0261 *	-10.2379 **	-12.6512 **	7.8718	55.3199 ***	-1.3007 ***	1.9832 **	-0.3159 ***					
fl	1242.01	-0.2458 ***	0.5563 ***	13.7338 *	-9.9336 **	-12.3279 **	8.0252	56.0574 ***	-1.3434 ***	2.0234 **	-0.3210 ***					
ga	1212.97	-0.2443 ***	0.5500 ***	13.7954 *	-9.8278 **	-12.2331 **	8.4280	56.1356 ***	-1.3309 ***	2.0517 **	-0.3223 ***					
hi	-2102.81 *	-0.1787 ***	0.4682 ***	0.7952	-0.5771	1.1933	12.6037	77.3049 ***	-1.6984 ***	4.0093 ***	-0.4564 ***					
id	-326.65	-0.2498 ***	0.4931 ***	8.0792	-3.6822	-6.6463	19.6522 **	71.2110 ***	-1.3081 ***	2.6478 ***	-0.3873 ***					
il	1041.09	-0.2472 ***	0.5412 ***	12.9028	-9.1897 *	-11.4369 **	9.9647	57.1173 ***	-1.3094 ***	2.1109 ***	-0.3285 ***					
in	1127.61	-0.2423 ***	0.5407 ***	13.6921 *	-9.6139 *	-11.8816 **	9.1452	56.4144 ***	-1.3058 ***	2.0562 **	-0.3234 ***					
ia	834.81	-0.2543 ***	0.5370 ***	11.6235	-8.2685 *	-10.5090 **	11.8625	58.6900 ***	-1.3044 ***	2.2151 ***	-0.3386 ***					
ks	602.37	-0.2680 ***	0.5439 ***	9.6029	-6.8146	-9.5079 **	14.1362	61.4360 ***	-1.3418 ***	2.3902 ***	-0.3567 ***					
ky	1161.89	-0.2431 ***	0.5438 ***	13.7419 *	-9.6842 *	-12.0267 **	8.9084	56.3069 ***	-1.3153 ***	2.0621 **	-0.3233 ***					
la	1007.54	-0.2631 ***	0.5606 ***	10.9795	-8.4563 *	-11.0324 **	10.6292	58.0821 ***	-1.3635 ***	2.2317 ***	-0.3394 ***					
me	1339.35	-0.2244 ***	0.5343 ***	16.1823 *	-10.7339 **	-13.0726 **	6.9275	54.2960 ***	-1.2721 ***	1.8208 **	-0.3065 ***					
md	1271.87	-0.2342 ***	0.5392 ***	15.0520 *	-10.2471 **	-12.6608 **	7.8568	55.2998 ***	-1.3001 ***	1.9813 **	-0.3158 ***					
ma	1312.14	-0.2292 ***	0.5362 ***	15.6756 *	-10.5060 **	-12.9059 **	7.3770	54.7732 ***	-1.2861 ***	1.9123 **	-0.3113 ***					
mi	1118.65	-0.2365 ***	0.5340 ***	14.2182 *	-9.8116 **	-11.9062 **	8.9259	56.0627 ***	-1.2807 ***	1.9816 **	-0.3188 ***					
mn	715.76	-0.2513 ***	0.5252 ***	11.7094	-8.0472 *	-10.0766 **	12.6523	59.0941 ***	-1.2702 ***	2.2034 ***	-0.3384 ***					
ms	1077.35	-0.2554 ***	0.5547 ***	12.0898	-8.9911 *	-11.4569 **	9.8749	57.3563 ***	-1.3471 ***	2.1668 ***	-0.3328 ***					
mo	929.07	-0.2560 ***	0.5453 ***	11.6457	-8.4868 *	-10.8556 **	11.1615	58.2529 ***	-1.3263 ***	2.2110 ***	-0.3376 ***					
mt	-131.22	-0.2536 ***	0.4902 ***	9.2294	-4.2250	-7.4401 *	19.9006 **	69.4634 ***	-1.2626 ***	2.5549 ***	-0.3811 ***					
ne	470.56	-0.2662 ***	0.5339 ***	9.5919	-6.3961	-9.0992 **	15.2236 *	62.5050 ***	-1.3220 ***	2.4143 ***	-0.3601 ***					
nv	-434.30	-0.2544 ***	0.5104 ***	6.2765	-3.0811	-5.9674	19.0328 **	71.7801 ***	-1.3710 ***	2.7121 ***	-0.3931 ***					
nh	1315.12	-0.2279 ***	0.5351 ***	15.7959 *	-10.5502 **	-12.9305 **	7.3137	54.6614 ***	-1.2810 ***	1.8924 **	-0.3102 ***					
nj	1289.26	-0.2322 ***	0.5380 ***	15.3112 *	-10.3539 **	-12.7666 **	7.6591	55.0883 ***	-1.2947 ***	1.9563 **	-0.3140 ***					
nm	162.63	-0.2753 ***	0.5439 ***	7.4484	-4.6222	-7.9974 *	17.1236 *	66.9050 ***	-1.3840 ***	2.5722 ***	-0.3817 ***					
ny	1281.45	-0.2307 ***	0.5355 ***	15.4175 *	-10.3731 **	-12.7433 **	7.6951	54.9975 ***	-1.2858 ***	1.9364 **	-0.3131 ***					
nc	1255.95	-0.2380 ***	0.5440 ***	14.6262 *	-10.1257 **	-12.5326 **	7.9966	55.5996 ***	-1.3138 ***	2.0048 **	-0.3179 ***					
nd	294.28	-0.2605 ***	0.5132 ***	10.0178	-6.0273	-8.5609 **	16.6132 **	63.3223 ***	-1.2668 ***	2.4039 ***	-0.3600 ***					
oh	1197.98	-0.2377 ***	0.5393 ***	14.4196 *	-9.9564 **	-12.2646 **	8.4916	55.8177 ***	-1.3002 ***	2.0092 **	-0.3191 ***					
ok	689.45	-0.2702 ***	0.5521 ***	9.4853	-7.0344	-9.7661 **	13.4313	60.8098 ***	-1.3587 ***	2.3780 ***	-0.3551 ***					
or	-717.86	-0.2412 ***	0.4869 ***	6.4916	-2.7951	-5.0314	19.6002 **	73.4101 ***	-1.3466 ***	2.7969 ***	-0.3948 ***					
pa	1261.03	-0.2336 ***	0.5376 ***	15.0706 *	-10.2344 **	-12.6156 **	7.9388	55.2897 ***	-1.2946 ***	1.9733 **	-0.3155 ***					
ri	1314.70	-0.2293 ***	0.5367 ***	15.6740 *	-10.5139 **	-12.9166 **	7.3468	54.7755 ***	-1.2875 ***	1.9118 **	-0.3112 ***					
sc	1243.83	-0.2404 ***	0.5468 ***	14.3356 *	-10.0357 **	-12.4388 **	8.1070	55.7872 ***	-1.3214 ***	2.0193 **	-0.3193 ***					
sd	390.09	-0.2634 ***	0.5242 ***	9.8061	-6.2279	-8.8642 **	15.8768 *	62.9379 ***	-1.2975 ***	2.4117 ***	-0.3603 ***					
tn	1147.09	-0.2461 ***	0.5469 ***	13.3685	-9.5425 *	-11.9145 **	9.0914	56.5440 ***	-1.3245 ***	2.0879 **	-0.3255 ***					
tx	602.86	-0.2793 ***	0.5632 ***	8.1547	-6.3050	-9.3079 **	14.0750	61.9834 ***	-1.3922 ***	2.4489 ***	-0.3639 ***					
ut	-129.01	-0.2612 ***	0.5170 ***	7.5564	-3.9109	-7.1829 *	18.6908 **	69.7094 ***	-1.3492 ***	2.6166 ***	-0.3866 ***					
vt	1306.22	-0.2282 ***	0.5346 ***	15.7310 *	-10.5131 **	-12.8847 **	7.4082	54.7185 ***	-1.2803 ***	1.8995 **	-0.3107 ***					
va	1256.18	-0.2365 ***	0.5414 ***	14.7759 *	-10.1509 **	-12.5567 **	8.0111	55.5072 ***	-1.3068 ***	1.9994 **	-0.3173 ***					
wa	-733.40	-0.2340 ***	0.4671 ***	7.7377	-3.0386	-5.2175	20.3000 **	73.7468 ***	-1.2951 ***	2.7883 ***	-0.3927 ***					
wv	1233.98	-0.2371 ***	0.5406 ***	14.6237 *	-10.0667 **	-12.4432 **	8.2164	55.6357 ***	-1.3048 ***	2.0071 **	-0.3182 ***					
wi	961.55	-0.2437 ***	0.5323 ***	13.0142	-9.1135 *	-11.1356 **	10.3777	57.2571 ***	-1.2807 ***	2.0769 **	-0.3270 ***					
wy	38.87	-0.2620 ***	0.5128 ***	8.7354	-4.6107	-7.8430 *	18.5153 **	67.8131 ***	-1.3103 ***	2.5417 ***	-0.3788 ***					
OLS																
	-54.42	-0.25 ***	0.55 ***	6.85	-7.08	-6.77	9.43	66.07 ***	-1.41 ***	2.58 ***	-0.34 ***	0.9514	0.9392		2.1642	51

Table 4. Results of Geographically Weighted Regression: Case of Agg_USC01-Agge_USC09

	Intercept	Agg_USC 1	Agg_USC 2	Agg_USC 3	Agg_USC4	Agg_USC5	Agg_USC6	Agg_USC7	Agg_USC 8	Agg_USC 9	Pop	M_temp	R_crime	HR_index	Disp_inc	Gov_exp	N_pub_12	N_pub_high	GSP_US C42	R_sq	Adj_R_sq	Bandwidth	DW	N
GWR																								
al	228.36	0.0038	0.2279***	0.4162	-0.0977***	-0.0946**	-0.0501**	-0.1013***	0.0132	0.0065	0.2192	7.9991	-5.4248	-5.7985	24.1105***	37.7551***	-0.2141	1.0084	-0.2769***	0.9837	0.9745	1.4316		51
ak	-1157.55	-0.0326	0.2640***	0.3315	-0.0956***	-0.1019**	-0.0376	-0.1158***	0.0145**	0.0505*	0.2068	3.6367	-5.5032**	0.4419	13.7571*	45.4586***	-0.5220	2.3796***	-0.3153***					
az	-194.03	-0.0198	0.2256***	0.2972	-0.0864***	-0.1074**	-0.0496**	-0.0986***	0.0093	0.0272	0.2622*	3.8964	-4.7036	-3.5317	19.1351**	42.5527***	-0.4769	1.6429*	-0.3084***					
ar	268.74	-0.0007	0.2223***	0.3897	-0.0941***	-0.0960**	-0.0514**	-0.0987***	0.0118	0.0075	0.2352*	7.6263	-5.4733	-5.8832	23.3320**	38.2332***	-0.2807	1.1123	-0.2820***					
ca	-505.71	-0.0246	0.2391***	0.2995	-0.0892***	-0.1074**	-0.0453*	-0.1030***	0.0103	0.0341	0.2433*	3.0170	-4.5657	-2.1367	18.1202**	43.4170***	-0.4734	1.8183*	-0.3106***					
co	19.02	-0.0148	0.2208***	0.3173	-0.0876***	-0.1026**	-0.0516**	-0.0966***	0.0093	0.0191	0.2601*	5.4995	-5.1797	-4.5969	20.6088**	41.2498***	-0.4363	1.4968*	-0.3006***					
ct	42.35	0.0061	0.2412***	0.4417	-0.1042***	-0.0923*	-0.0466*	-0.1055***	0.0147*	0.0072	0.1896	8.1085	-5.3764	-5.0930	25.1313***	37.7738***	-0.1205	0.9439	-0.2721***					
de	61.73	0.0056	0.2397***	0.4379	-0.1033***	-0.0928*	-0.0470*	-0.1050***	0.0145*	0.0074	0.1935	8.0241	-5.3571	-5.1529	24.9723***	37.7715***	-0.1338	0.9573	-0.2729***					
dc	71.42	0.0053	0.2390***	0.4358	-0.1028***	-0.0930*	-0.0471*	-0.1047***	0.0144*	0.0074	0.1952	8.0131	-5.3645	-5.1871	24.9067***	37.7773***	-0.1403	0.9647	-0.2733***					
fl	231.26	0.0069	0.2288***	0.4314	-0.0992***	-0.0939**	-0.0500**	-0.1026***	0.0140	0.0057	0.2138	8.2609	-5.3952	-5.8711	24.4555***	37.4987***	-0.1823	0.9372	-0.2739***					
ga	187.60	0.0052	0.2313***	0.4264	-0.0996***	-0.0940**	-0.0493**	-0.1026***	0.0138	0.0065	0.2110	8.0825	-5.3961	-5.6579	24.4402***	37.6661***	-0.1842	0.9744	-0.2750***					
hi	-1165.63	-0.0329	0.2532***	0.3262	-0.0903***	-0.1138**	-0.0380	-0.1139***	0.0132*	0.0543**	0.2336	1.9335	-4.6372*	0.5435	12.6434	47.3588***	-0.5711	2.3631***	-0.3260***					
id	-356.83	-0.0214	0.2357***	0.3068	-0.0900***	-0.1041**	-0.0473*	-0.1012***	0.0102	0.0287	0.2425*	4.2432	-4.9566	-2.9007	19.2382**	42.6438***	-0.4486	1.7197**	-0.3058***					
il	210.22	0.0012	0.2285***	0.4045	-0.0974***	-0.0938**	-0.0499**	-0.1003***	0.0126	0.0066	0.2199	8.0091	-5.5573	-5.7103	24.0570**	37.9964***	-0.2296	1.0540	-0.2782***					
in	179.43	0.0031	0.2315***	0.4166	-0.0992***	-0.0933**	-0.0492**	-0.1017***	0.0132	0.0065	0.2119	8.1333	-5.5216	-5.6176	24.3948**	37.8435***	-0.1981	1.0127	-0.2762***					
ia	220.68	-0.0034	0.2249***	0.3785	-0.0944***	-0.0948**	-0.0508**	-0.0980***	0.0113	0.0077	0.2324*	7.6241	-5.6064	-5.6727	23.3995**	38.5071***	-0.2876	1.1545	-0.2829***					
ks	214.61	-0.0079	0.2188***	0.3509	-0.0901***	-0.0983**	-0.0522**	-0.0963***	0.0101	0.0110	0.2515*	6.8240	-5.4573	-5.5410	22.1728***	39.4605***	-0.3656	1.2917	-0.2905***					
ky	174.81	0.0037	0.2318***	0.4202	-0.0994***	-0.0936**	-0.0491**	-0.1021***	0.0134	0.0067	0.2110	8.0752	-5.4638	-5.5953	24.4060***	37.7973***	-0.1924	1.0034	-0.2759***					
la	309.35	0.0006	0.2199***	0.3926	-0.0935***	-0.0964**	-0.0520**	-0.0986***	0.0120	0.0071	0.2391*	7.6584	-5.4284	-6.0574	23.2415***	38.0860***	-0.2838	1.0899	-0.2816***					
me	49.36	0.0079	0.2415***	0.4497	-0.1055***	-0.0908*	-0.0465*	-0.1058***	0.0151*	0.0061	0.1859	8.4786	-5.4673	-5.1913	25.4278***	37.6829***	-0.0999	0.8980	-0.2700***					
md	69.14	0.0053	0.2392***	0.4360	-0.1029***	-0.0930*	-0.0471*	-0.1047***	0.0144*	0.0074	0.1949	8.0132	-5.3642	-5.1782	24.9171***	37.7793***	-0.1394	0.9643	-0.2733***					
ma	39.90	0.0063	0.2415***	0.4432	-0.1045***	-0.0921*	-0.0465*	-0.1056***	0.0148*	0.0071	0.1887	8.1543	-5.3857	-5.0924	25.1848***	37.7642***	-0.1163	0.9370	-0.2717***					
mi	164.50	0.0033	0.2331***	0.4185	-0.1003***	-0.0919*	-0.0488*	-0.1017***	0.0133	0.0058	0.2074	8.3551	-5.6157	-5.5909	24.6512***	37.8179***	-0.1840	0.9934	-0.2749***					
mn	190.19	-0.0058	0.2261***	0.3666	-0.0943***	-0.0940**	-0.0506**	-0.0972***	0.0109	0.0078	0.2323*	7.5647	-5.6957	-5.5235	23.3761***	38.7063***	-0.2990	1.1878	-0.2839***					
ms	263.49	0.0021	0.2245***	0.4046	-0.0958***	-0.0953**	-0.0509**	-0.1000***	0.0126	0.0068	0.2280*	7.8518	-5.4411	-5.9076	23.7268***	37.9089***	-0.2467	1.0498	-0.2791***					
mo	242.62	-0.0014	0.2242***	0.3879	-0.0947***	-0.0952**	-0.0510**	-0.0987***	0.0118	0.0074	0.2320*	7.6789	-5.5344	-5.7806	23.4598***	38.3025***	-0.2760	1.1209	-0.2818***					
mt	-165.51	-0.0186	0.2282***	0.3040	-0.0887***	-0.1023**	-0.0504**	-0.0982***	0.0096	0.0237	0.2519*	5.2718	-5.2717	-3.8245	20.0183**	42.1295***	-0.4497	1.6196*	-0.3037***					
ne	163.98	-0.0101	0.2201***	0.3407	-0.0899***	-0.0985**	-0.0520**	-0.0961***	0.0098	0.0124	0.2519*	6.6485	-5.4810	-5.3106	21.9648**	39.8652***	-0.3808	1.3446	-0.2926***					
nv	-416.07	-0.0227	0.2372***	0.3048	-0.0896***	-0.1060**	-0.0462*	-0.1021***	0.0102	0.0309	0.2429*	3.5390	-4.6997	-2.5618	18.8051**	42.8821***	-0.4564	1.7517**	-0.3078***					
nh	41.77	0.0066	0.2415***	0.4442	-0.1047***	-0.0917*	-0.0465*	-0.1056***	0.0148*	0.0069	0.1880	8.2372	-5.4130	-5.1141	25.2413**	37.7510***	-0.1132	0.9304	-0.2714***					
nj	53.11	0.0056	0.2403***	0.4390	-0.1036***	-0.0927*	-0.0468*	-0.1051***	0.0146*	0.0074	0.1920	8.0468	-5.3649	-5.1228	25.0259**	37.7796***	-0.1294	0.9546	-0.2727***					
nm	39.82	-0.0150	0.2172***	0.3109	-0.0859***	-0.1045**	-0.0522**	-0.0961***	0.0090	0.0200	0.2689*	5.1593	-5.0380	-4.6498	20.1660**	41.5156***	-0.4585	1.5064*	-0.3029***					
ny	59.41	0.0057	0.2402***	0.4387	-0.1037***	-0.0922*	-0.0469*	-0.1049***	0.0145*	0.0070	0.1919*	8.1702	-5.4192	-5.1662	25.0782**	37.7727***	-0.1289	0.9518	-0.2724***					
nc	116.33	0.0055	0.2361***	0.4335	-0.1017***	-0.0934*	-0.0480*	-0.1040***	0.0142	0.0070	0.2008	8.0534	-5.3701	-5.3729	24.7560**	37.7109***	-0.1546	0.9626	-0.2737***					
nd	108.33	-0.0129	0.2225***	0.3263	-0.0900***	-0.0974**	-0.0518**	-0.0954***	0.0095	0.0129	0.2504*	6.6503	-5.6083	-5.0709	21.9505**	40.1747***	-0.3930	1.3905	-0.2938***					
oh	136.66	0.0044	0.2348***	0.4266	-0.1010***	-0.0929*	-0.0483*	-0.1030***	0.0138	0.0066	0.2039	8.1749	-5.4769	-5.4630	24.6845**	37.7730***	-0.1693	0.9832	-0.2745***					
ok	254.70	-0.0063	0.2173***	0.3573	-0.0901***	-0.0984**	-0.0525**	-0.0964***	0.0104	0.0103	0.2527*	6.9201	-5.4254	-5.7196	22.2401**	39.2023***	-0.3587	1.2563	-0.2893***					
or	-552.42	-0.0246	0.2424***	0.3065	-0.0910***	-0.1049**	-0.0447*	-0.1040***	0.0107	0.0336	0.2346*	3.5342	-4.8151	-2.0127	18.2799**	43.3611***	-0.4590	1.8450**	-0.3084***					
pa	76.66	0.0052	0.2388***	0.4351	-0.1029***	-0.0927*	-0.0472*	-0.1045***	0.0143	0.0072	0.1954	8.0937	-5.4047	-5.2191	24.9300**	37.7790***	-0.1414	0.9652	-0.2733***					
ri	40.96	0.0064	0.2414***	0.4436	-0.1045***	-0.0921*	-0.0465*	-0.1056***	0.0148*	0.0071	0.1887	8.1516	-5.3802	-5.0971	25.1847***	37.7574***	-0.1159	0.9351	-0.2717***					
sc	146.29	0.0055	0.2342***	0.4315	-0.1009***	-0.0936**	-0.0485*	-0.1035***	0.0141	0.0068	0.2047	8.0820	-5.3786	-5.4966	24.6481***	37.6750***	-0.1649	0.9628	-0.2741***					
sd	133.70	-0.0114	0.2215***	0.3347	-0.0900***	-0.0980**	-0.0518**	-0.0959***	0.0097	0.0128	0.2507*	6.6419	-5.5366	-5.1816	21.9573***	40.0268***	-0.3855	1.3682	-0.2932***					
tn	196.94	0.0034	0.2301***	0.4172	-0.0986***	-0.0941**	-0.0495**	-0.1017***	0.0133	0.0067	0.2149	8.0242	-5.4520	-5.6745	24.2546***	37.8037***	-0.2043	1.0117	-0.2765***					
tx	284.74	-0.0075	0.2115***	0.3436	-0.0874***	-0.1006**	-0.0536**	-0.0952***	0.0098	0.0116	0.2668*	6.5359	-5.3168	-5.8022	21.5018***	39.6728***	-0.4025	1.3033	-0.2931***					
ut	-228.76	-0.0195	0.2301***	0.3070	-0.0885***	-0.1051**	-0.0487*	-0.0996***	0.0097	0.0262	0.2514*	4.2890	-4.8692	-3.4270	19.5712**	42.2506***	-0.4506	1.6423*	-0.3054***					
vt	45.58	0.0064	0.2413***	0.4429	-0.1045***	-0.0918*	-0.0466*	-0.1054***	0.0147*	0.0069	0.1887	8.2379	-5.4226	-5.1273	25.2140**	37.7567***	-0.1165	0.9353	-0.2716***					
va	96.27	0.0052	0.2374***	0.4336	-0.1021***	-0.0932*	-0.0476*	-0.1042***	0.0142*	0.0072	0.1986	8.0306	-5.3740	-5.2876	24.8092**	37.7528***	-0.1500	0.9678	-0.2737***					
wa	-554.41	-0.0246	0.2423***	0.3044	-0.0911***	-0.1040**	-0.0451*	-0.1039***	0.0108	0.0337	0.2345*	3.8474	-4.9698	-2.0531	18.2061**	43.4624***	-0.4635	1.8596**	-0.3084***					
wv	111.73	0.0048	0.2364***	0.4307	-0.1017***	-0.0931*	-0.0479*	-0.1038***	0.0141	0.0070	0.2007	8.0775	-5.4112	-5.3530	24.7516**	37.7625***	-0.1581	0.9754	-0.2741***					
wi	197.19	-0.0003	0.2293***	0.3968	-0.0975***	-0.0927**	-0.0498**	-0.0995***	0.0122	0.0062	0.2193	8.0753	-5.6659	-5.6546	24.1156**	38.0991***	-0.2348	1.0688	-0.2784***					
wy	-77.90	-0.0167	0.2252***	0.3121	-0.0884***	-0.1025**	-0.0507**	-0.0976***	0.0095	0.0213	0.2547*	5.3405	-5.2019	-4.1824	20.3893**	41.6389***	-0.4386	1.5549*	-0.3019***					
OLS																								
	-659.74	-0.0138	0.2680***	0.3941	-0.1052**	-0.0990	-0.0369	-0.1107***	0.0139	0.0221	0.1654	4.1389	-4.5561	-1.6195	23.0428**	40.4999**	-0.1739	1.4253	-0.2843***	0.9804	0.9693		2.2441	51

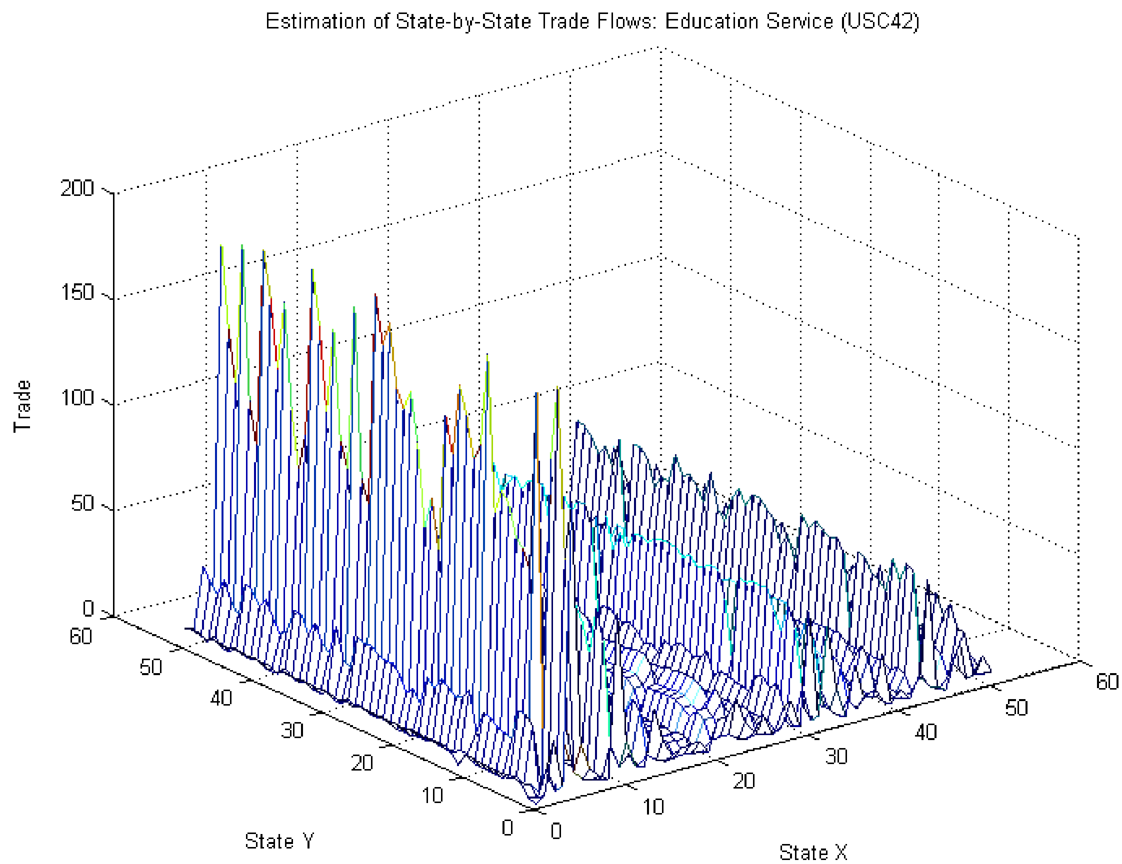
Figure 1. The Estimated and Actual Domestic Imports for The USC Sector 42, Education Service, by Each State



Note: yhat= $y^{h}_{USC\,42}$ and y= $y_{USC\,42}$.

Another important result from Table 3 is that more domestic imports of commodities (mean_agg) negatively affects the domestic imports of education services. Further, Table 4 shows that commodity characteristics differently affect education services for each state. This is different from the general belief that higher commodity trades induce more service trades, and therefore more cautious approaches require, for example, when using the average coefficient of commodities for the coefficient of service sectors. Therefore, this result might be helpful to understand which commodity in domestic import is more appropriate to induce an aimed service sector by each state.

Figure 2. Estimation of State-by-State Trade Flows: Case of Education Service, USC Sector 42



Note: Order of State follows the order in Table A2.

Exclude the main diagonal trade, that is, intrastate movements from the estimated trade flows T^{*}_{USC42}.

Because the adjusted R-square in Table 4 is higher than that in Table 3, dependent variable is estimated based on the coefficients in Table 4 and the given independent variables. Figure 1 shows the estimated (y^h_{USC42}) and actual (y_{USC42}) domestic imports for education service (USC Sector 42) by each state. This figure shows that the GWR regressions reflecting the spatial effects.

Based on the optimized bandwidth from Table 4, 1.4316, the state-by-state trade flows are obtained as shown in Figure 2. The trade flows in Figure 2 does not involve the main diagonal in the trade matrix, $\hat{T}$, to adjust the magnitude of trade into the figure. Therefore, this net state-by-state trade flows, $\tilde{T}^*$, for education services sector shows the amount of net domestic import by each state (State X) and the estimated results of domestic exports by each state (State Y). All trade flows for USC Sector 42, T^*_{USC42} , are obtained adding the $\hat{T}_{USC42}$ to $\tilde{T}^*_{USC42}$.

However, this is only 'net domestic import based GWR' application. This might induce the necessity of constraining the estimated exports from the trade matrix according to State Y coordinate upon the actual net domestic exports available from the IMPLAN dataset. While the current approach is one-way constrained GWR model relying on domestic import, hence, the doubly-constrained GWR estimation might be helpful, if these partial constrained models are not enough.

5 Conclusions and Remarks

Limited access to data on services trade flows has restricted estimating the economic interrelationships of the services between regions. The rapid increases in telecommunication, especially web-based industries, however, require us to investigate the amount of trades between regions. Although there are various suggestions on how to estimate service trade flows, most have focused on the estimation of non-service sectors along with strong assumptions on limited service trades.

In this paper, I overviewed the studies and methodologies dealing with the estimation of state-by-state trade flows for the U.S. Still, due to limitations of service sector information and its own characteristics, and depending on different transport trends from commodities an alternative methodology is required. To estimate the state-by-state trade flows of service sectors, this study applied Geographically Weighted Regressions, which was elaborated by LeSage. The approach applied here reflects other factors as well as distance with respect to trade flows, and hence is more appropriate to estimating trade flows for service sectors. In an application to the education services industry, the GWR estimation shows that it well explains the net domestic imports for each state.

However, this approach must be tested more extensively 1) based on actual trade data and its sum, and 2) constrained by net domestic exports. Furthermore, it should be noted that because the bandwidth, θ, reflects all the independent effects, more independent variables would increase bandwidth and decease the distance effects.

In spite of the possible problems, the application of this approach answers many key issues addressed in regional science. Here, at least three applications can be discussed, beyond service sector estimation. GWR can be used to estimate the economic interrelationship between sub-state regions. In fact, Lindall et al (2005) estimate trade flows at the county level, the GWR can provide an alternative result for trade flows at the same or at lower levels, based on secondary data, but only if there are net in- or out-bound data. This makes it possible for a new MRIO-type model at the sub-state level to be constructed. Second, the application of GWR supports the estimation of trade flows for services sectors without resorting to severe assumptions, but in the same way as non-service sector estimation. That is, the GWR approach can be consistently extended to other estimates of industry sectors. Third, because the GWR includes statistical probabilities for the results, these can support discussions of reasonable criteria to determine which model should be selected. Finally, due to the nature of econometrics, the approach can be used to predict potential trade flow. In this case, the GWR can be applied to adjust the four- or five-year based CFS data to a one-year base. Furthermore, with appropriate changes in independent variables for a targeted regional economy, the GWR can be used to forecast changes in various trade flows and hence key changes within an MRIO. Therefore, a dynamic MRIO model also can be constructed and run according to reasonable scenarios. This can support more plausible results on long-term effects as well as for short-term effects. Therefore, the application of GWR to the estimation trade flows has many more implications than only as an alternative trade flows' methodology. These should be elaborated and investigated.

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Appendices

Table A1. Definition of USC sector

Classification	USC	Description	SCTG	NAICS	Agg_USC*
Commodity Sectors	USC01	Live animals and live fish & Meat, fish, seafood, and their preparations	(1+5)		Agg_USC 01
	USC02	Cereal grains & Other agricultural products except for Animal Feed	(2+3)		
	USC03	Animal feed and products of animal origin, n.e.c.	4		
	USC04	Milled grain products and preparations, and bakery products	6		Agg_USC 02
	USC05	Other prepared foodstuffs and fats and oils	7		
	USC06	Alcoholic beverages	8		
	USC07	Tobacco products	9		
	USC08	Nonmetallic minerals (Monumental or building stone, Natural sands, Gravel and crushed stone, n.e.c	(10~13)		Agg_USC 03
	USC09	Metallic ores and concentrates	14		
	USC10	Coal and petroleum products (Coal and Fuel oils, n.e.c.)	(15~19)		Agg_USC 04
	USC11	Basic chemicals	20		
	USC12	Pharmaceutical products	21		Agg_USC 05
	USC13	Fertilizers	22		
	USC14	Chemical products and preparations, n.e.c.	23		
	USC15	Plastics and rubber	24		
	USC16	Logs and other wood in the rough & Wood products	(25+26)		Agg_USC 06
	USC17	Pulp, newsprint, paper, and paperboard & Paper or paperboard articles	(27+28)		
	USC18	Printed products	29		
	USC19	Textiles, leather, and articles of textiles or leather	30		
	USC20	Nonmetallic mineral products	31		Agg_USC 07
	USC21	Base metal in primary or semi-finished forms and in finished basic shapes	32		
	USC22	Articles of base metal	33		
	USC23	Machinery	34		
	USC24	Electronic and other electrical equipment and components, and office equipment	35		Agg_USC 08
	USC25	Motorized and other vehicles (including parts)	36		
	USC26	Transportation equipment, n.e.c.	37		
	USC27	Precision instruments and apparatus	38		
	USC28	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs	39		Agg_USC 09
	USC29	Miscellaneous manufactured products, Scrap, Mixed freight, and Commodity unknown	(40~99)		
Non-Commodity (Service) Sectors	USC30	Utility		22	
	USC31	Construction		23	
	USC32	Wholesale Trade		42	
	USC33	Transportation		48	
	USC34	Postal and Warehousing		49	
	USC35	Retail Trade		(44+45)	
	USC36	Broadcasting and information services**		(515~519)	
	USC37	Finance and Insurance		52	
	USC38	Real estate and rental and leasing		53	
	USC39	Professional, Scientific, and Technical services		54	
	USC40	Management of companies and enterprises		55	
	USC41	Administrative support and waste management		56	
	USC42	Education Services		61	
	USC43	Health Care and Social Assistances		62	
	USC44	Arts, Entertainment, and Recreation		71	
	USC45	Accommodation and Food services		72	
	USC46	Public administration		92	
	USC47	Other services except public administration***		81	

*Agg_USC sectors are defined basically at the basis of SCTG groups aggregated from the SCTG sectors suggested by CFS.

**Publishing, Motion pictures, and Recording (IMPLAN 413-415, 417-419, or NAICS 511~512) are excluded in this sector and included in Commodity Sectors.

***USC47 includes NAICS 81plus Support activities (18=Agriculture and forestry, 27-29=Mining) and Etc. (243=Machine shops) in IMPLAN.

Table A2. Total Domestic Import for each state by USC service sector, 2001

	Total Domestic Import ($M.)																	
States	USC30	USC31	USC32	USC33	USC34	USC35	USC36	USC37	USC38	USC39	USC40	USC41	USC42	USC43	USC44	USC45	USC46	USC47
Alabama	543	264	3863	2800	591	1948	3933	7630	5352	6217	1979	2607	354	3000	1291	1221	77	2723
Alaska	199	392	1069	320	138	377	691	1693	1184	1010	302	713	176	663	107	147	2	516
Arizona	924	1302	2081	2001	568	1808	3886	7309	4684	4470	785	2168	1327	4132	929	960	40	1985
Arkansas	1196	943	2921	1612	444	1262	2156	4762	3818	4245	967	1621	238	1498	630	672	49	1661
California	9822	1535	0	18856	5037	10892	31050	45651	33537	26788	4088	12150	7064	32388	3729	9017	398	14561
Colorado	419	0	26	2307	656	1702	5830	7428	5318	4799	676	2530	1067	4366	537	1041	218	2307
Connecticut	533	17	917	2949	569	1859	4617	11327	3935	3390	558	1208	451	2982	762	2438	392	1957
Delaware	175	0	1221	546	184	366	1117	2450	1142	1655	328	700	240	474	201	279	35	1089
District of Columbia	394	954	1380	955	326	1493	2674	1179	1937	5684	58	999	100	679	314	228	11	1051
Florida	3771	1642	3137	7518	2307	3771	13028	20815	15025	9211	2007	5334	3485	8950	2187	3367	164	6008
Georgia	1743	4171	222	3819	1077	1885	8338	11195	8258	8285	1604	3904	797	9305	1759	1940	422	3923
Hawaii	462	34	679	782	207	399	1078	2199	1477	1070	184	1201	273	989	177	280	4	472
Idaho	719	49	930	599	253	371	1013	2217	1456	1515	265	735	185	1042	219	234	26	706
Illinois	3135	1758	151	5016	1757	5398	13196	18628	15360	8003	1738	4395	1354	7749	1452	5202	218	7008
Indiana	1920	1386	6847	4006	808	1759	5671	11515	7286	9865	2086	3870	621	2607	931	1913	480	4060
Iowa	680	994	2545	2455	493	663	2911	6009	5038	4847	1585	1778	253	1227	420	752	72	2183
Kansas	340	690	1348	1765	598	766	3165	4800	4532	4825	873	1584	351	1192	634	1119	12	2216
Kentucky	1993	3653	4268	3051	1020	1579	3401	7574	7211	6090	1429	2753	379	2083	976	1095	103	5529
Louisiana	1821	65	4393	2376	693	1833	3536	7706	7825	5201	1475	1885	367	3191	708	919	115	2674
Maine	712	0	1402	632	217	365	1082	2587	2206	1779	474	974	109	575	236	285	40	813
Maryland	550	373	3671	3157	812	2283	6284	9867	5572	6321	1891	2304	755	2919	1354	1565	34	2239
Massachusetts	1572	81	736	4873	995	3556	7153	13078	8674	5466	882	3343	782	4002	1495	2881	327	4230
Michigan	651	585	12032	7707	1549	2722	9062	19065	12850	10110	1901	3920	1131	4134	1180	3402	202	15148
Minnesota	1949	366	75	2943	837	1438	5447	8379	5247	4602	746	2164	547	3054	782	1546	304	2407
Mississippi	971	677	3271	1369	351	1055	2094	4510	4639	4144	969	1704	282	2553	492	479	74	1838
Missouri	2270	1170	1197	2213	670	2064	5584	8217	6374	4739	714	2744	578	2232	785	1679	120	3246
Montana	63	146	1095	492	223	574	653	1686	1943	1212	373	746	108	416	160	167	4	623
Nebraska	434	402	985	1148	392	457	1640	3528	3988	2661	397	860	232	1054	288	514	9	1346
Nevada	597	1099	1549	1078	318	665	1914	4390	2481	2541	482	1429	807	3015	404	503	28	1436
New Hampshire	358	19	1270	1021	149	267	1300	2760	1732	1785	360	749	130	656	188	332	6	817
New Jersey	2201	180	695	4058	1292	3641	10338	19217	9259	6448	1240	2942	2587	4879	1188	6148	173	5328
New Mexico	391	223	1397	743	300	575	1205	3012	2350	3034	481	637	251	1536	355	306	5	919
New York	3998	10040	245	10923	4086	16928	19595	30360	22585	12713	2132	6908	2172	12325	4158	12501	986	13114
North Carolina	4235	839	5178	4415	1021	2185	7138	14470	11854	12818	3572	5571	709	5614	1378	2208	225	4320
North Dakota	122	46	811	391	191	240	614	1508	2033	1055	199	524	64	371	149	127	3	694
Ohio	5079	2338	32098	5793	1609	2398	10180	21463	13362	12546	2579	5225	1137	5403	1308	4412	129	7462
Oklahoma	331	216	2559	1655	850	1235	2917	5753	6091	3438	1272	1455	379	1587	887	938	42	2108
Oregon	709	277	5	1531	449	926	2893	5584	3450	2722	483	1381	371	1621	563	816	21	1854
Pennsylvania	2808	150	5997	5546	1526	3301	12600	22469	13757	9357	2744	5079	1216	6828	2181	4308	804	5375
Rhode Island	456	114	1383	911	259	999	938	1509	1264	1805	408	973	100	543	224	385	49	482
South Carolina	1285	91	4575	2238	404	926	3294	7376	4595	5730	1808	3513	316	3966	658	749	142	2565
South Dakota	221	298	461	416	222	301	707	1556	1598	1329	264	668	73	478	125	154	9	686
Tennessee	2209	619	2301	2242	1072	1199	4844	8831	5994	7766	2270	2915	496	3079	771	1173	304	4263
Texas	2010	12419	656	8619	4265	4768	19921	30191	31899	15693	11788	8329	2472	21272	4247	7845	885	12304
Utah	559	273	530	869	228	438	1653	3596	2102	2742	430	983	207	873	307	399	62	892
Vermont	185	2	866	359	64	269	537	1225	965	838	249	418	54	322	140	125	10	371
Virginia	2279	2791	7688	3805	1047	3211	12620	13757	8867	16023	1210	6589	771	4114	1737	1909	155	3469
Washington	1187	744	1368	3120	881	1475	6381	9666	6751	8799	1543	4575	1405	4968	788	1428	27	2944
West Virginia	325	522	1928	1249	443	793	1222	3511	3811	2739	867	1119	244	1159	534	329	24	1392
Wisconsin	2453	721	5183	3134	751	1869	5287	10804	8280	7100	1464	2609	599	2967	959	1537	47	3634
Wyoming	65	1938	608	343	137	326	422	1191	1022	752	415	328	188	1018	159	104	3	365

Table A3. Total Intrastate Flows for each state by USC service sector, 2001

	Total Intrastate Flows ($M.)																	
States	USC30	USC31	USC32	USC33	USC34	USC35	USC36	USC37	USC38	USC39	USC40	USC41	USC42	USC43	USC44	USC45	USC46	USC47
Alabama	5291	13080	7892	4207	1662	11262	2623	8081	15920	8047	908	3233	1450	15512	940	5861	17399	7538
Alaska	1188	2568	703	934	269	1686	691	1034	2769	1572	246	754	148	2198	291	1095	5346	2012
Arizona	4392	21040	8772	4655	1999	14633	3826	11669	22157	12809	1833	5184	794	17131	1969	7374	18875	8370
Arkansas	2451	7492	4820	3123	1111	6427	1688	4119	9033	3425	1000	1795	779	9170	623	3448	8499	4749
California	34240	113187	92054	35305	14978	107249	33588	100130	178847	147085	17140	44211	13837	131932	19812	56412	148559	72959
Colorado	5825	23659	12234	4918	2224	15114	6074	14688	25392	18432	2213	6471	1287	17467	2492	7841	21009	10662
Connecticut	4125	10625	9649	2867	1788	12412	3065	11726	21036	13455	2330	4640	1830	17429	1828	5612	14637	7787
Delaware	823	2623	992	748	358	2418	382	1624	3738	1944	285	503	176	3323	299	1260	3103	1467
District of Columbia	608	1166	771	537	583	1352	1654	2518	5203	8100	255	2170	305	3329	318	1334	29316	757
Florida	15266	61392	31009	15934	6212	51189	13541	44063	77395	44613	6153	20015	3960	65757	7153	25576	55520	29119
Georgia	9589	29535	22220	10513	4259	25170	9070	22548	39317	26226	4321	10263	3140	27561	2998	13183	35944	16759
Hawaii	1117	3221	1734	1086	374	3366	821	2235	5334	3203	370	1338	278	4194	499	1953	8301	1988
Idaho	816	4925	2429	1357	400	3561	733	2323	5083	2426	466	977	319	4166	439	1791	5203	2095
Illinois	14489	42939	37724	17957	6637	38377	9807	42589	65136	45513	7333	16690	5376	53685	6378	20137	45637	26703
Indiana	6635	20413	14489	8022	2894	17621	3590	12933	26596	11300	2920	4706	2176	23806	2623	8799	19265	12716
Iowa	3708	8842	7472	3270	1445	8701	1788	7813	11594	5486	647	2449	1061	11601	1217	4524	10806	5600
Kansas	3601	8752	7338	3220	1285	7980	2208	6815	12008	6007	1143	2566	964	10939	884	3798	11520	6446
Kentucky	3732	12373	8387	4062	1339	10741	2579	7330	14376	7069	1528	3105	1401	15228	1276	5753	16044	6772
Louisiana	4286	13659	6917	6013	1665	11463	3002	7755	16453	13083	2025	4056	1475	15560	1666	6216	17459	12828
Maine	1016	4096	1878	1286	464	3906	814	2419	4501	2100	373	741	441	5111	456	1916	4613	2152
Maryland	5900	20824	9462	4799	2890	17711	4799	13039	27296	23856	964	7348	2218	24116	2041	9051	37630	10868
Massachusetts	6993	19796	18493	6296	3397	21621	6692	20775	36955	28231	3771	8905	3210	32493	3015	11443	24400	12984
Michigan	12283	29594	20271	8845	4376	29314	6677	20565	44338	27726	5528	10332	3933	40618	4651	14705	33780	21930
Minnesota	5469	18177	16708	6299	2665	16365	3843	16791	27141	17481	3162	6782	2143	21575	2413	8752	18972	11506
Mississippi	2675	7058	3751	2794	1007	6610	1524	4181	7934	4027	753	1422	745	8367	833	3663	10729	4583
Missouri	5496	19326	15135	7624	2787	16445	5030	15330	26285	17145	3036	5702	2086	23531	2402	8532	20255	12504
Montana	1150	3214	1075	954	258	2238	641	1556	3005	1908	115	587	259	3334	330	1288	4050	1720
Nebraska	2222	6410	4748	2741	835	5379	1433	5211	7017	4405	850	1718	596	6920	751	2662	6653	3667
Nevada	1954	10857	2759	1801	795	6828	1437	4425	9648	4946	674	2105	138	6390	875	3278	7985	3167
New Hampshire	1211	4233	2430	840	610	4404	829	2881	5930	3209	605	1195	530	5607	583	2182	3650	2279
New Jersey	8762	24158	22786	10838	4439	28598	8807	22208	47825	35013	5222	11364	2677	40850	4522	11914	33732	17919
New Mexico	1574	5728	2382	1454	473	4614	1210	2700	6349	4334	454	1902	419	5587	554	2330	10245	3727
New York	22222	49269	47720	18073	8402	52731	21014	68582	109290	67412	8957	27700	8823	91354	9882	28108	75004	34500
North Carolina	6824	32743	18902	9015	3599	24515	6621	16729	33565	15607	3786	5749	2902	29993	3019	12064	35760	14789
North Dakota	888	1911	1117	807	268	1790	451	1332	2019	1122	259	487	238	2433	221	975	3146	1467
Ohio	10498	34529	3168	13950	5303	34605	8141	26667	51525	30141	6067	12478	4200	45892	5312	16151	39581	25072
Oklahoma	4161	9167	6100	3952	1427	9190	2953	6752	13735	7624	1129	3174	1016	13085	983	4596	15132	9987
Oregon	3636	10779	9096	3869	1441	10307	2426	7838	15942	8455	1585	3613	1178	13607	1355	5271	12790	6492
Pennsylvania	14322	38568	30104	15347	6103	39075	9164	34601	60965	40652	6058	14513	4967	53170	5106	19319	37744	25134
Rhode Island	702	2004	1277	551	281	2409	667	2947	4613	1585	203	467	405	4467	371	1521	4196	1773
South Carolina	4011	14614	6090	3830	1585	11451	2234	6767	15074	6059	970	2020	1296	12497	1400	5648	17052	6738
South Dakota	789	2680	1838	824	248	2205	519	1619	2937	1058	227	441	265	2942	304	1168	3174	1399
Tennessee	5453	17181	15164	8182	2553	17322	4439	14269	25586	11770	2071	5636	2032	22351	2479	8832	17765	11271
Texas	29573	85768	58470	29786	9539	65311	19810	62619	105661	78198	4291	29883	7773	74207	7870	31345	83390	61441
Utah	1785	7747	4903	2476	952	6000	1606	4859	8895	6087	1021	2107	658	7390	845	3013	9861	3873
Vermont	568	2171	794	567	285	1840	416	1146	2448	1429	183	473	220	2500	229	965	2339	1045
Virginia	7769	29985	12589	8673	3269	22471	10021	16274	35291	38778	3746	9688	2989	30539	2702	12256	47789	15012
Washington	6892	21850	15628	7044	2556	19476	4382	15620	28674	17463	2106	5829	1726	23741	2807	10011	27977	11909
West Virginia	2057	4926	2414	1723	410	4448	1154	2232	5236	2647	326	967	473	6304	504	2399	7039	3148
Wisconsin	5308	17478	13807	6931	2645	15987	3159	13743	22218	12085	3128	5225	1950	21476	2134	8458	19368	10910
Wyoming	710	2473	729	687	148	1484	336	816	2399	1167	74	361	45	1341	228	796	2728	2091

Note: Values are revised by adding foreign imports to the calculated domestic products supported from the 2001 IMPLAN data.