

Okun's Law and Urban Spillovers

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Abstract

Using 358 Metropolitan Statistical Areas (MSA) during the period 2002-2010, we estimate a regional Okun's Law after accounting for national shocks and spatial spillovers. Our main finding is that MSA-specific growth has a tiny effect on MSA unemployment rate implying that in a well-integrated labor market like the United States, unemployment at an urban level is highly dependent on surrounding and national labor and goods markets conditions. State level data confirms our previous result. Additionally, the change in the scale of measurement allow us to compare the efficiency of the estimators when the MAUP is present.

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I. Introduction

Arthur Okun's (1962) influential paper opened the debate on the empirical link between unemployment and output. Ever since, a large number of empirical and theoretical papers on the so called Okun's Law have showed that a decrease of one percentage point in the unemployment rate is associated with a two to three percent growth in real gross domestic product (GDP)¹. Knotek (2007) and Gordon (2010) for example use time series technique to analyze the stability of this relationship for the United States. Kaufman (1988) and Moosa (1997) compares the Okun's coefficient among industrialized countries concluding that differences in responses of unemployment to changes in GDP are due to labor productivity and labor force participation rate, rigidities in the labor market and other institutional differences. Although Okun's Law is primarily a statistical relationship, Gordon (1984), Prachowny (1993), Attfield and Silverstone (1997) provided the microfoundations for this relationship based on production function approaches.

At a regional level Blackley (1991) finds the Okun's coefficient for the 26 largest states in the US, supporting –on average- the result mentioned in the previous paragraph. The author concluded that inter-state differences in the distribution of age and gender of the labor force, different tax policies and industries lead to differences in Okun's coefficient among states. On the other hand Freeman (2000) found little differences in Okun's coefficients for states in the US. Other attempts to find the Okun's Law using regional data are those by Adanu (2005) for Canada, Christopoulos (2004) for Greece and Maza and Villaverde (2009) for Spain. All of them found a fairly large and negative relationship between unemployment and GDP for most regions.

¹ Weber (1995) stresses the sensitivity of this coefficient to model specifications and econometric techniques. Neely (2010) provides a great example of recent informal estimates of Okun's coefficient from six industrialized countries.

Finally Yazgan and Yilmazkuday (2009) provided evidence for the spatial convergence of the Okun's coefficient over time within the United States.

Although the previous papers shed some light on the regional Okun's coefficient, we cannot abstract from the fact that in a well-integrated labor market regional unemployment may be dependent on unemployment in neighboring areas. Molho (1995) for instance suggests that labor migration and commuting are the two economic reasons behind the observed spatial dependence in the unemployment rate in the UK. As a result, a rise in GDP growth in a given area can reduce unemployment rates in neighboring areas. Likewise, Blanchard and Katz (1992) pointed to labor migration as the predominant mechanism to reach equilibrium between state unemployment rates following economic shocks.

The aim of this study is to compute the Okun's Law at the metropolitan statistical area level (MSA) in the US accounting for national time effects and spatial spillovers in a panel dataset. Additionally, we use different specifications for the weight matrix to check the robustness of our results. Our findings support the existence of an integrated labor market at a national level rather than the predominance of urban labor markets.

We also compare our results with state-level data for three reasons. One, most of the commuting happens within the MSAs; however, an MSA could be spread across several state lines that can form a source of spatial dependence in state data that is not present at a lower level of aggregation. Two, MSAs are smaller geographical units than states which should lead to relatively higher labor mobility between them than between states. The two previous reasons should change the degree of spatial dependence at these two different scales. Three, the comparison allow us to analyze empirically the Modifiable Areal Unit Problem (MAUP) that deals with the arbitrariness and irregularity of spatial areal data. It is well known in the spatial

econometric literature that the estimation results vary with the aggregation and resolution level of the data. Studies like Arbia (1989) and Arbia and Petrarca (2011) show that conclusions derived at one level of aggregation and resolution may not hold at a different level. Our results are consistent with these studies. The effect of state-specific growth on unemployment seems to be larger than that of the MSA.

In the following section we do some preliminary data analysis, lay out the formal spatial models and describe the data and estimation techniques. Section III discusses the estimation results. In section IV we outline the implications of section III and we conclude in section V.

II. The Data and Model Specifications

a. Preliminary data analysis

The basic differenced version of Okun's law that we use is the following:

$$1. \quad \Delta U_t = \beta_1 + \beta_2 \Delta \ln p_t + \varepsilon_t$$

Where ΔU is the change in unemployment rate, $\Delta \ln p$ is the change in the natural log of real GDP, t is a time index where $t = 1..T$, and ε represents the error term ($\varepsilon \sim N(0, \sigma^2)$). The

Okun's coefficient is calculated as $\frac{-1}{\beta_2}$; we use a minus sign because we expect β_2 to be

negative.

When we extend this to a panel data set, the basic model is as follows:

$$2. \quad \Delta U_{i,t} = \beta_1 + \beta_i + \beta_t + \beta_2 \Delta \ln p_{i,t} + \varepsilon_{i,t}$$

where β_i accounts for region-specific fixed effects and β_t accounts for time effects. Introducing fixed time effects allow us to control for changes that take place at a national level. Another way

of doing it is to explicitly introduce a variable that captures these changes such as national GDP growth.

Equation 3 shows our model adjusted for national growth:

$$3. \quad \Delta U_{i,t} = \beta_1 + \beta_i + \beta_n \Delta gdp^n + \beta_2 \Delta gdp_{i,t} + \varepsilon_{i,t}$$

where Δgdp^n represents the real GDP growth rate for the entire US economy excluding region i .

Econometrically, omission of spatial variables in spatially dependent data leads to biased least squares estimates; therefore in the next section we develop formal spatial econometric models that enable us to capture these spillovers.

b. Spatial model specification

As LeSage and Pace (2009) shows, unobserved common properties between spatial neighbors that are associated with other explanatory variables can be modeled as a Spatial Durbin Model; thus we extend equation 2 to allow for spatial dependence by specifying the Panel Spatial Durbin Model (hereafter PSDM):

$$4. \quad \Delta U_{i,t} = \beta_1 + \beta_i + \beta_t + \beta_2 \Delta gdp_{i,t} + \theta \sum_{j=1}^N w_{i,j} \Delta gdp_{j,t} + \rho \sum_{j=1}^N w_{i,j} \Delta U_{j,t} + \varepsilon_{i,t}$$

Where $i = 1 \dots N$, ε represents the idiosyncratic term ($\varepsilon \sim \text{MVN}(0, \sigma^2 I_n)$), ρ measures the spatial

dependence in the dependent variable. Finally, $\sum_{j=1}^N w_{i,j} \Delta gdp_{j,t}$ and $\sum_{j=1}^N w_{i,j} \Delta U_{j,t}$ are the spatial

feedbacks of real GDP growth and change in unemployment rate. They are the weighted average of the values of real GDP growth and change in unemployment rate for the neighbors of region i .

To model the spatial spillovers, we use different definitions for the weight matrix. This let us check the robustness of our results. Before explaining each of our weight matrices, it is worth

mentioning that all of them have zero on the main diagonal and the entire matrix is normalized in such a way that the individual rows sum up to one.

For the first weight matrix for the MSA's, we define any element $w_{i,j} \forall i \neq j$ as one if and only if MSA i is a neighbor of MSA j , and zero otherwise; however MSA's do not have a common border, for this reason we define neighboring MSA's as any two MSA's that are inside a range. For our particular case the range is 196 miles; this range is not completely arbitrary since is the minimum that ensures that any MSA has at least one neighbor. The second matrix uses the same neighboring definition as the first one, but instead of being a binary matrix is computed using the inverse distance squared. That is, for any element $w_{i,j} = \frac{1}{d^2_{i,j}} \forall i \neq j$ where d is the distance in miles between MSA i and MSA j . Finally in spite of the differences in socio-demographic properties, we can assume that migration also takes place beyond nearby areas; for this reason our third matrix is calculated as the inverse distance squared for all MSA's, in other words for any element $w_{i,j} = \frac{1}{d^2_{i,j}} \forall i \neq j$ where d is the distance in miles between MSA i and MSA j . It should be clear that the second matrix differs from the third one that in the former the parameter d cannot exceed 196 miles.

In the case of states, the first weight matrix was constructed according to the first order queen's definition. In other words, it has one if and only if state i have a common border with state j , and zero otherwise. The second matrix is calculated as the inverse distance squared for all states, in other words for any element $w_{i,j} = \frac{1}{d^2_{i,j}} \forall i \neq j$ where d is the distance in miles between state i and state j . As was mentioned before all these weight matrices (either for MSA's or states) have been row standardized.

As a final note, in the PSDM specified in equation 4, we allow for a spatial lag of GDP growth and a spatial lag of the dependent variable. Two special cases are worth mentioning. If the coefficient ρ is restricted to zero, we have a panel SLX model. If θ is restricted to zero, we have a panel spatial autoregressive model (SAR). If we restrict both coefficients to zero, we get back the simple panel model described in equation 2. We use the AIC to compare empirical performance of the different model specifications.

c. Data description

The annual data for 358 MSA's and 48 mainland states of the United States over the period 2002-2010 were obtained from the Bureau of Economic Analysis and the Bureau of Labor Statistics. We do not consider MSA's from Alaska, Hawaii or Puerto Rico. We used maximum likelihood procedures to estimate the PSDM since the least squares estimates will be biased.

III. Estimation Results

As LeSage and Dominguez (2012) pointed out, “there is no need to provide empirical evidence on how inappropriate OLS models are to justify the use of a spatial regression model”; nonetheless we report the results from equations two and three in order to obtain a broader understanding of the regional Okun's coefficient.

a. MSA level

The first two columns of table 1 show the results from the model in equation two. Both coefficients are fairly large in spite of their relative low value compared with “standard” results. More interesting are those reported in third and fourth columns. When time effects or national growth are included, the Okun's coefficient drops to one third of its initial value. These results are important for three reasons. First, it is a clear signal that growth experiences that take place at

a national level have a strong impact at finer resolution level. Second, considering time effects seems to be as informative as explicitly controlling for national GDP growth. Third, given that time effects seems to be enough to control for shocks at national level, and given that the coefficient effect estimates in a spatial setup already captures spillovers through the weight matrix from other regions; the GDP growth variable will be dropped, additionally this enable us to keep the parsimony of the model, .

Tables 2, 3 and 4 present the estimates from the PSDM using the three different weight matrix specifications. The most important result is that for all the models, indirect effect is larger than direct effect. The reason for this result comes from the fact that indirect effect is cumulative; in other words, sums up the spillover on all regions. A second outcome is the large and statistically significant value of rho signaling high spatial autocorrelation on unemployment. Also, the AIC favors the model with inverse distance squared weight matrix for MSA's within 196 miles and controlling for state and time fixed effects. We can observe that in this particular model indirect effect is as much as twice the direct effect. These results stress the importance of modeling spatial spillovers and national effects on the regional Okun's Law.

b. State level

We now turn our attention to state level data, which is also a labor market with almost non-existing frictions to labor migration. Like the MSA's, we have a market with only small cultural differences, a common language and almost completely free labor mobility. There is, however, one crucial difference between these two aggregation levels. Each state has its own fiscal policy, meanwhile MSA's do not. Put another way, each state has its own fiscal tools that could be used to attract investment and increase employment. Furthermore MSA's that cross state's borders are subject to more than one fiscal policy. The last statements open a new channel

of spatial dependence since residents are free to choose the mix of government policies (LeSage and Dominguez 2012) implying that inter-state migration could happen without affecting migration at the MSA level.

The results are shown in tables five through seven. Unlike MSA, we can observe in table five that the Okun's coefficient without spatial spillovers is closer to the standard results observed in the literature. However, as in the case of MSA, including time effects or national growth drops the Okun's coefficient to one third of its value.

As before, the spatial models show a high, positive and statistically significant value for rho, meaning that unemployment is spatially autocorrelated. Also the indirect effect is larger than the direct effect, being at least 2.5 times bigger. Finally the AIC favors the use of state and time fixed effects regardless of the definition used to obtain the weight matrix. Once again, the importance of computing spatial spillovers and national shocks are of paramount importance when calculating a regional Okun's Law.

IV. Result's implications

Comparing the results at different scales, we observe that the direct effect is larger for states than for MSA's even when we include time effects. We can also observe that in all cases the coefficient for GDP spillovers is at least twice that of state's GDP. The implication of these results depends on the motivation behind the analysis. For example a state policy maker will be interested in observing the effect on its own state's unemployment of a demand driven policy, thus paying attention to the direct effect. However, from a public policy analysis, the interest will be focused on the total effect. To illustrate this point; the results in the second column of table seven shows that a one percent increases in state's GDP will decrease the unemployment rate only by 0.08 in the same state, but 0.45 if we account for spillovers on other states. This last

result indicates that if a state i increases its GDP by roughly 2.2 percent, a decrease on the unemployment rate of one percentage point will take place, a relationship that is within the boundaries of the standard Okun's coefficient. We should keep in mind though that the decrease in unemployment does not take place entirely in the same state where the increase in GDP occurred, but in several states. It should be clear now that the policy implications of an increase in a region's GDP is dependent upon the policy analysis.

Second, the results suggest that even though state-specific growth seems to have a larger impact than MSA-specific growth on their own respective unemployment rate, both are still heavily dependent on national and regional growth experiences.

A third implication is the higher value of rho when moving from state to MSA level. According to the empirical literature, as spatial units become larger, spatial dependence falls as shown in Anselin and Rey (2010). In our case the two source of spatial dependence in unemployment are due to labor migration and commuting. Assuming that labor migration is the driving force behind spatial dependence on unemployment, our results indicate that inter-urban migration is higher than inter-state migration, thus the higher value of rho when using MSA data.

Finally our data set provides a good empirical example to test the MAUP. Changing the scale of our observations and moving to a coarser level of aggregation motivates a loss in efficiency on our coefficients. To see this, we compare tables four and seven since they have the same inverse distance squared weight matrix. We observe that the standard errors associated with the computed coefficients are at least for times lower when using MSA data than when using state data. However the loss in efficiency associated with the change in scale should not represent a problem since is mitigated by the presence of positive spatial autocorrelation as shown in Arbia and Petrarca (2011)

V. Conclusions

In this study we estimated Okun's Law from an urban perspective using Metropolitan Statistical Areas. Results show that MSA growth has a small effect on MSA unemployment. Furthermore, unemployment rates are heavily dependent on other regional growth experiences and national conditions. Overall, the policy implications depend on the aim of the policy makers and whether their objectives are state-wise or national-wise.

One possible reason for this pattern could be industry clusters; for example MSA's in the oil states (Texas, Louisiana and Oklahoma) may be affected by the same shocks. Moreover, specialization of the labor force on a given industry allows unemployed workers to move to a different geographical area within the industry cluster, intensifying the spatial dependence on unemployment. The other possible explanation is similar to that outlined by Blanchard and Katz (1992) that regional labor markets adjust quickly to shocks, attracting (expelling) workers and thus affecting the labor market. This would imply the existence of a powerful well-connected national labor market with regional labor markets being far less important.

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Table 1: Panel Estimates of Okun's Law without Spatial Effects

	Common Intercept	MSA Effects	MSA and time Effects	MSA and national effects
GDP growth	-0.164 (0.005)*	-0.181 (0.006)*	-0.062 (0.004)*	-0.055 (0.004)*
National growth	-	-	-	-0.559 (0.008)*
Log-Likelihood	-5069.49	-4980.49	-2961.23	-3465.52
AIC	3.148	3.314	2.066	2.375

Note: The dependent variable is annual change in the unemployment rates of 358 MSA's for the period 2002-2010. Annual growth in the real GDP nationally and by MSA was used as the independent variables. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance.

Table 2: Panel Estimates of Okun's Law from Spatial Durbin Model.

	MSA Effects	MSA and Time Effects
GDP growth	-0.040 (0.003)*	-0.041 (0.003)*
WGDP growth	-0.018 (0.005)*	-0.003 (0.007)*
Direct Effect	-0.054 (0.003)*	-0.046 (0.003)*
Indirect Effect	-0.414 (0.032)*	-0.129 (0.025)*
Total Effect	-0.468 (0.033)*	-0.175 (0.026)*
ρ	0.876 (0.009)*	0.746 (0.016)*
Log-Likelihood	-2432.89	-2343.11
AIC	1.73	1.68

Note: The dependent variable is annual change in the unemployment rates of 358 MSA's for the period 2002-2010. Independent variables are MSA's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance. MSA's within 196 miles are considered neighbors.

Table 3: Panel Estimates of Okun's Law from Spatial Durbin Model.

	MSA Effects	MSA and Time Effects
GDP growth	-0.041 (0.003)*	-0.041 (0.003)*
WGDP growth	-0.021 (0.005)*	-0.001 (0.005)
Direct Effect	-0.063 (0.003)*	-0.047 (0.003)*
Indirect Effect	-0.346 (0.023)*	-0.088 (0.016)*
Total Effect	-0.409 (0.024)*	-0.135 (0.017)*
ρ	0.848 (0.008)*	0.692 (0.014)*
Log-Likelihood	-2409.39	-2238.10
AIC	1.72	1.62

Note: The dependent variable is annual change in the unemployment rates of 358 MSA's for the period 2002-2010. Independent variables are MSA's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisked (*) parameter estimates are statistically significant at 5 percent level of significance. Inverse distance squared weight matrix constructed with MSAs within 196 miles.

Table 4: Panel Estimates of Okun's Law from Spatial Durbin Model.

	MSA Effects	MSA and Time Effects
GDP growth	-0.040 (0.003)*	-0.041 (0.003)*
WGDP growth	0.002 (0.006)	-0.005 (0.009)
Direct Effect	-0.045 (0.003)*	-0.048 (0.003)*
Indirect Effect	-0.465 (0.060)*	-0.458 (0.113)*
Total Effect	-0.510 (0.061)*	-0.506 (0.114)*
ρ	0.926 (0.010)*	0.908 (0.013)*
Log-Likelihood	-2322.26	-2305.98
AIC	1.66	1.66

Note: The dependent variable is annual change in the unemployment rates of 358 MSA's for the period 2002-2010. Independent variables are MSA's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisked (*) parameter estimates are statistically significant at 5 percent level of significance. Inverse distance squared weight matrix constructed with all MSAs.

Table 5: Panel Estimates of Okun's Law without Spatial Effects.

	Common Intercept	State Effects	State and Time Effects	State and National Effects
GDP growth	-0.287 (0.018)*	-0.314 (0.019)*	-0.088 (0.013)*	-0.094 (0.016)*
National growth	-	-	-	-0.493 (0.022)*
Log-Likelihood	-592.42	-576.57	-298.89	-390.36
AIC	2.752	2.896	1.648	2.039

Note: The dependent variable is annual change in the unemployment rates of 48 contiguous States for the period 2002-2010. Annual growth in the real GDP nationally and by state was used as the independent variable. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance.

Table 6: Panel Estimates of Okun's Law from Spatial Durbin Model.

	State Effects	State and Time Effects
GDP growth	-0.049 (0.012)*	-0.054 (0.012)*
WGDP growth	-0.116 (0.019)*	-0.087 (0.022)*
Direct Effect	-0.090 (0.012)*	-0.066 (0.012)*
Indirect Effect	-0.460 (0.038)*	-0.166 (0.035)*
Total Effect	-0.550 (0.042)*	-0.232 (0.040)*
ρ	0.698 (0.032)*	0.394 (0.053)*
Log-Likelihood	-304.19	-263.85
AIC	1.64	1.49

Note: The dependent variable is annual change in the unemployment rates of 48 States for the period 2002-2010. Independent variables are state's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance. Weight matrix based on first order contiguity.

Table 7: Panel Estimates of Okun's Law from Spatial Durbin Model.

	State Effects	State and Time Effects
GDP growth	-0.061 (0.013)*	-0.066 (0.013)*
WGDP growth	-0.103 (0.029)*	-0.148 (0.048)*
Direct Effect	-0.084 (0.012)*	-0.081 (0.013)*
Indirect Effect	-0.569 (0.054)*	-0.371 (0.100)*
Total Effect	-0.653 (0.057)*	-0.452 (0.104)*
ρ	0.747 (0.041)*	0.515 (0.069)*
Log-Likelihood	-294.92	-276.02
AIC	1.60	1.55

Note: The dependent variable is annual change in the unemployment rates of 48 States for the period 2002-2009. Independent variables are state's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance. Inverse distance squared weight matrix constructed with all states.

Additional Estimation Results

The following five tables, Table A1, A2 A3, A4 and A5 show the estimates from panel SAR models.

Table A1: Panel Estimates of Okun's Law from Spatial Autoregressive Model. MSA's within 200 miles are considered neighbors.

	MSA Effects	MSA and Time Effects
GDP growth	-0.043 (0.003)*	-0.041 (0.003)*
Direct Effect	-0.054 (0.003)*	-0.046 (0.003)*
Indirect Effect	-0.348 (0.029)*	-0.121 (0.013)*
Total Effect	-0.402 (0.031)*	-0.167 (0.015)*
ρ	0.893 (0.007)*	0.751 (0.016)*
Log-Likelihood	-2437.81	-2343.29
AIC	1.74	1.68

Note: The dependent variable is annual change in the unemployment rates of 358 MSA's for the period 2002-2010. Independent variables are MSA's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance. MSAs within 196 miles are considered neighbors.

Table A2: Panel Estimates of Okun’s Law from Spatial Autoregressive Model. Weight matrix based on inverse distance squared.

	MSA Effects	MSA and Time Effects
GDP growth	-0.040 (0.003)*	-0.041 (0.003)*
Direct Effect	-0.046 (0.003)*	-0.047 (0.003)*
Indirect Effect	-0.466 (0.053)*	-0.495 (0.092)*
Total Effect	-0.513 (0.054)*	-0.542 (0.094)*
ρ	0.922 (0.008)*	0.923 (0.012)*
Log-Likelihood	-2322.34	-2306.68
AIC	1.66	1.66

Note: The dependent variable is annual change in the unemployment rates of 358 MSA’s for the period 2002-2010. Independent variables are MSA’s real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisked (*) parameter estimates are statistically significant at 5 percent level of significance. Inverse distance squared weight matrix constructed with MSAs within 196 miles.

Table A3: Panel Estimates of Okun’s Law from Spatial Autoregressive Model. Weight matrix based on inverse distance squared.

	MSA Effects	MSA and Time Effects
GDP growth	-0.045 (0.003)*	-0.040 (0.003)*
Direct Effect	-0.062 (0.003)*	-0.047 (0.003)*
Indirect Effect	-0.277 (0.019)*	-0.094 (0.008)*
Total Effect	-0.339 (0.022)*	-0.140 (0.011)*
ρ	0.868 (0.007)*	0.714 (0.013)*
Log-Likelihood	-2418.49	-2239.72
AIC	1.72	1.62

Note: The dependent variable is annual change in the unemployment rates of 358 MSA’s for the period 2002-2010. Independent variables are MSA’s real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisked (*) parameter estimates are statistically significant at 5 percent level of significance. Inverse distance squared weight matrix constructed with all MSAs.

Table A4: Panel Estimates of Okun's Law from Spatial Autoregressive Model. Weight matrix based on inverse distance squared.

	State Effects	State and Time Effects
GDP growth	-0.074 (0.010)*	-0.064 (0.012)*
Direct Effect	-0.103 (0.014)*	-0.068 (0.013)*
Indirect Effect	-0.315 (0.053)*	-0.053 (0.015)*
Total Effect	-0.418 (0.063)*	-0.121 (0.026)*
ρ	0.821 (0.022)*	0.473 (0.049)*
Log-Likelihood	-323.14	-272.70
AIC	1.73	1.53

Note: The dependent variable is annual change in the unemployment rates of 48 contiguous states for the period 2002-2010. Independent variables are state's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance. Weight matrix based on first order contiguity.

Table A5: Panel Estimates of Okun's Law from Spatial Autoregressive Model. Weight matrix based on inverse distance squared.

	State Effects	State and Time Effects
GDP growth	-0.077 (0.011)*	-0.074 (0.012)*
Direct Effect	-0.096 (0.012)*	-0.079 (0.013)*
Indirect Effect	-0.493 (0.095)*	-0.106 (0.033)*
Total Effect	-0.589 (0.102)*	-0.184 (0.041)*
ρ	0.865 (0.021)*	0.589 (0.062)*
Log-Likelihood	-302.78	-282.79
AIC	1.63	1.57

Note: The dependent variable is annual change in the unemployment rates of 48 contiguous states for the period 2002-2010. Independent variables are state's real GDP growth rate and spatially weighted GDP (WGDP) growth rate. Standard errors are reported in the parentheses. Asterisk (*) parameter estimates are statistically significant at 5 percent level of significance. Inverse distance squared weight matrix constructed with all states.