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ORIGINAL PAPER

The role of spatial GDP spillovers in state-level Okun's law

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Abstract Trade and labor mobility linkages in an economic union suggest the possibility of spatial GDP spillovers in empirical models of state-level Okun's law. We expand and estimate the state-level Okun's law with spatial GDP spillovers and national output growth. The estimates of state-specific GDP growth effect on state unemployment rate changes drop substantially in the expanded models. State GDP growths that are associated with regional and national GDP growths have much bigger effect on state unemployment rates. The models show a large improvement in the fit of the regressions. The results are primarily driven by employment changes and not by labor force changes. The results support the need for coordination in state-level economic policies.

Keywords Okun's law · State unemployment · State GDP · Spatial spillovers

JEL Classification E23 · E24 · C21

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1 Introduction

Output market and labor market conditions are critical inputs for policymakers at national and local levels. The crucial empirical link between output and unemployment is provided by Okun's law, introduced in Okun (1962)[1]. Since then it has been a vital component of simple macroeconomic models for policy discussions. An important issue facing the regional policymaker is how the local labor market conditions are shaped by the local economy and how much the national conditions matter for the local market. Better econometric model specifications of state-level Okun's law can provide essential quantitative information on this issue.

State level estimations of Okun's law are often treated as direct applications of time series national level models. Blackley (1991), Freeman (2000), Guisinger et al. (2015) use time series data and methods to analyze US states and regions. Adanu (2005), Christopoulos (2004), Villeverde and Maza (2009) take a similar approach to estimate regional Okun's law for Canada, Greece and Spain respectively. However, several studies with a regional/urban approach (e.g. Fogli et al. 2013; Molho 1995), argue that interstate trade, migration and commuting linkages can give rise to spatial economic spillovers in the output and labor markets. We use the regional approach to include spatial GDP spillovers and national GDP growth to adapt the state level Okun's law models.

Our estimates show that national GDP growth has a large effect on state unemployment rate changes. Compared to the simple state level Okun's law models, the fit of the regressions in spatial models of Okun's law are substantially higher. Moreover, the coefficients of the state specific GDP growth in the spatial models become much smaller relative to the simple models. The results are primarily driven by employment changes and not by labor force changes. These results relate to the Carlino and Inman (2013) study on macro-fiscal policy coordination from the Okun's law context and support the need for coordination in state-level economic policies.

In the next section, Sect. 2, we introduce the spatially adapted Okun's law model and describe the data. In Sect. 4, we present the panel estimation results for U3 and U6 unemployment rates, employment and labor force along with state specific estimation results. We conclude in Sect. 5.

2 The model specifications and the data

2.1 Empirical model specification

The basic differenced version of Okun's law for panel data with state specific fixed effects is the following equation[2]:

[1] Even though 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.

[2] The main alternative to this specification is the output gap version. The comparable references for US state level analysis are Blackley (1991) and Yazgan and Yilmazkuday (2009). Both use the differenced version. The empirical results of the gap version are available on request.

$$\Delta U_{i,t} = \beta_1 + \beta_i + \beta_2 \Delta gdp_{i,t} + \varepsilon_{i,t} \quad (1)$$

where ΔU is the change in unemployment rate, Δgdp is the change in the natural log of real GDP, t is the time subscript and the subscript i denotes the given state . Very few of the regional studies use formal spatial econometric models to estimate Okun's law. Yazgan and Yilmazkuday (2009) use spatial techniques to examine geographical convergence of the Okun's coefficient over time within the US. The simplest expansion of the basic panel model from Eq. 1 is to allow for national GDP growth and spatial GDP spillovers as follows[3]:

$$\Delta y_{i,t} = \beta_1 + \beta_i + \beta_2 \Delta gdp_{i,t} + \theta \sum_{j=1}^{N} w_{i,j} \Delta gdp_{i,j,t} + \lambda \Delta rgdp_{i,t} + \varepsilon_{i,t} \quad (2)$$

where $\Delta y_{i,t}$ is the dependent variable, $\sum_{j=1}^{N} w_{i,j} \Delta gdp_{i,j,t}$ is the weighted average of the values of real GDP growth for the neighbors (denoted by subscript j) of state i. The variable $\Delta rgdp_{i,t}$ represents real GDP growth in the remaining states beyond state i and the neighboring states. The neighboring states and the non-neighboring US states together form the US real GDP beyond the state i. The dependent variable is mostly the first difference of the state i unemployment rate. However, we do use employment and labor force variables as dependent variables in further analysis.

We model the spatial spillovers using a 48×48 first order queen spatial contiguity matrix denoted as W. This matrix contains either one or zero depending on whether or not a specific state shares a common border with another state. So, the element $w_{i,j}$ of this matrix is one if state i is a neighbor of state j, and is zero otherwise. There are two features of this matrix: the main diagonal is consists of only zeros (as a state is not its own neighbor) and the entire matrix is normalized such that the individual rows sum up to one. Given that the rows add up to one, all the neighbors of a specific state have the same spatial weight (i.e. if there are four neighbors of a given state, each neighbor will have a weight of 0.25).

3 The data description

The annual data on real GDP, employment, labor force, population and U3 unemployment rates for 48 contiguous states of the United States over the period 1987–2014 was obtained from Bureau of Economic Analysis and Bureau of Labor Statistics[4]. The data for U6 unemployment rates, the broadest measure of labor force underutilization that includes discouraged workers, marginally attached workers and partially

[3] We experimented with other types of spatial spillover modeling. Our primary results remain robust to those modeling features. We decided to use the simplest representation while preserving the economic factors. Please refer to LeSage and Kelly (2009) for an overview and Kuscevic (2014) for a discussion of those modeling features using city level data.

[4] The data on quantity indexes of state GDP are available from 1977. However, we cannot construct our rest of the US GDP variable with the quantity indexes. We did analyze that data with just time effects replacing for rest of the US GDP growth. Our basic results remain similar.

Table 1 Descriptive statistics and state-level estimates of Okun's law

Panel A:	Mean	Median	SD
U3	−0.015	−0.200	0.972
U6	0.145	−0.400	2.061
GDP growth	2.590	2.404	2.791
Panel B:		U3	U6
GDP growth		−0.160 (0.01)*	−0.448 (0.03)*
R^2		0.201	0.310
N		1296	528

The dependent variable U3 denotes annual change in the U3 unemployment rates for the period 1988–2014, by state. The dependent variable U6 denotes annual change in the U6 unemployment rates for the period 2004–2014, by state. Annual growth in the real GDP by state was used as the independent variable. Regressions include state level fixed effects. Panel corrected standard errors with cross section weights are reported in the parentheses

* Parameter estimates are statistically significant at 5% level of significance

employed workers, are from 2003 to 2014. We do not consider Alaska and Hawaii. The Bureau of Economic Analysis does not suggest merging the entire data on real GDP since a methodological change to measure GDP was introduced in 1998. However, subsample analysis that divides our sample between pre 1998 and post 1998 do not alter our results. The results we present in this study are based on the entire data set. The descriptive statistics of unemployment rate changes and GDP growth rates data are reported in Panel A of Table 1.

4 Estimation results for state-level Okun's law

We start our analysis by estimating the simple Okun's law model in Eq. 1 for U3 and U6 unemployment rate changes with state fixed effects. The estimates are reported in Panel B of Table 1. As expected, both results show a moderately large, and statistically significant, negative coefficients of state GDP growth. The regressions fits are also reasonable. In Table 2 we present the results for the model in Eq. (2) with spatial GDP spillovers. It includes a spatial lag of GDP growth and rest of the US GDP growth. The estimates show that the effect of a 1% increase in state GDP growth on U3 unemployment rate is small; about −0.04% reduction. This is much smaller than the state estimates in Table 1, around one-fourth in size. The impact of spatial spillover of GDP growth (WGDP growth) is similar; about 0.05% reduction. Finally, the coefficient estimate of rest of the US GDP growth (RGDP growth) on state unemployment rate is −0.24, much larger than the other two coefficient estimates. It implies that a 1% increase in state growth that is associated with regional and national growth decreases the state unemployment rate by 0.33%. A restricted version of the model, constraining the rest of the US GDP growth effect to be zero, show a large fall in the fit of the regression when compared to the unrestricted version. Moreover, the coefficients estimates of own GDP growth and neighboring state GDP growth are larger now as they are positively correlated with the omitted rest of the US GDP growth.

Table 2 State-level estimates of Okun's law with spatial GDP spillovers

	U3	U3	U6	U6
GDP growth	−0.039 (0.01)*	−0.068 (0.01)*	−0.095 (0.03)*	−0.185 (0.03)*
WGDP growth	−0.045 (0.02)*	−0.187(0.01)*	−0.144 (0.05)*	−0.590 (0.05)*
RGDP growth	−0.241 (0.02)*	–	−0.716 (0.06)*	–
R^2	0.382	0.309	0.628	0.506
N	1296	1296	528	528

The dependent variable U3 denotes annual change in the U3 unemployment rates for the period 1988–2014, by state. The dependent variable U6 denotes annual change in the U6 unemployment rates for the period 2004–2014, by state. Independent variables are state real GDP growth rates, spatially weighted GDP (WGDP) growth rates of the neighboring states and rest of the 48 US states GDP (RGDP) growth rates. Regressions include state level fixed effects. Panel corrected standard errors with cross section weights are reported in the parentheses

* Parameter estimates are statistically significant at 5% level of significance

These estimates highlight that time series based approach of state level Okun's law, following Blackley (1991), Freeman (2000), Guisinger et al. (2015), can potentially benefit by building in the regional factors in the models.

The pattern of the results is similar for U6 unemployment rate reported in the third and fourth columns of Table 2 although the size of the coefficients is much bigger (in absolute terms) than the U3 results. The U6 results use a different sample size due to data availability but it also suggests that our results are not sensitive to sampling horizons. A big feature of both U3 and U6 unrestricted spatial models is the rise in the regression fit over the simple model in Table 1. Comparison of R^2s with the unrestricted models show almost doubling of fit in both cases. Overall, the model with spatial GDP spillovers provide quantitatively important and robust evidence of the large role played by the economic growth in other states in a state's labor market, as stressed by Molho (1995), Fogli et al. (2013). These results provide support to the Carlino and Inman (2013) study on macro-fiscal policy indicating the need for coordination in state-level economic policies from an Okun's law perspective.

Next, we take a closer look at our evidence on spatial GDP spillovers by estimating the Eqs. (1) and (2) by state. While this reduces our sample size drastically, it also allows us to have state specific coefficients of the regressors. We present the histograms of state GDP coefficients in Fig. 1. The light grey bars show the state GDP coefficients from the simple Okun's law model in Eq. (1). The dark grey and patterned bars show the histogram of state GDP coefficients from the spatial GDP spillover model in Eq. (2). A comparison of the histograms show how the distribution shifted to the right to become much smaller in magnitude when we allowed for spatial GDP spillovers. The heterogeneity in the Okun's law coefficients is consistent with Blackley (1991) and Guisinger et al. (2015). In Fig. 2, we present the state GDP growth coefficients from Eq. (2) as light grey bars for each state. The black bars in Fig. 2 show the sum of the three coefficients in Eq. (2) representing total GDP growth effects. The pattern in that graph shows that the total GDP effects are much larger than the state GDP effects for almost all states. Overall, our basic panel data results are robust to state level estimations although state level results highlight a moderate heterogeneity in outcomes.

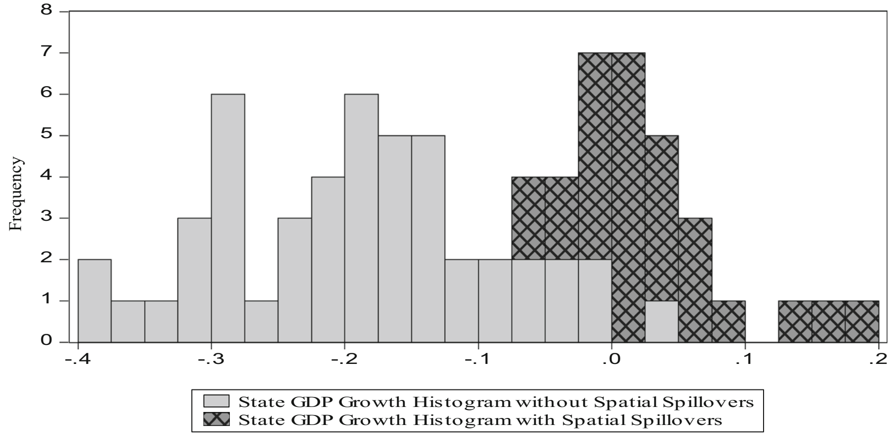

Fig. 1 Histogram of state GDP growth coefficients. *Note* The *light grey bars* show the histogram of estimated state real GDP growth coefficients by state without spatial GDP spillover effects. The *dark grey patterned bars* show the histogram of estimated state real GDP growth coefficients by state with spatial GDP spillover effects

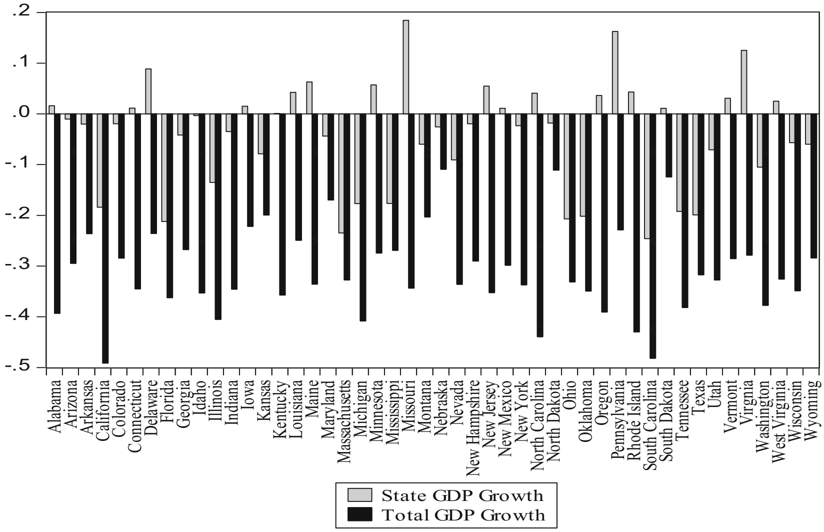

Fig. 2 Comparison of state GDP growth coefficients with spatial spillovers. *Note* The *light grey bars* show the estimated state real GDP growth coefficients for each state with spatial GDP spillover effects. The *black bars* show the sum of estimated coefficients of state real GDP growth rates, spatially weighted GDP (WGDP) growth rates of the neighboring states and rest of the 48 US states GDP (RGDP) growth rates for each state. The states are arranged alphabetically on the *horizontal axis*

Finally, we estimate Eq. (2) again for two sets of employment and labor force variables as dependent variables. The small effect of state-specific GDP growth is consistent with the Blanchard and Katz (1992) study showing high regional labor mobility in the US. A low labor mobility economy would have exactly the opposite pattern of estimates. However, a study by Partridge and Rickman (2006) show that

Table 3 Spatial GDP spillovers in employment and labor force

	EPR	LFPR	E	LF
GDP growth	0.063 (0.01)*	0.040 (0.01)*	0.179 (0.02)*	0.137 (0.02)*
WGDP growth	0.060 (0.02)*	0.030 (0.01)*	0.130 (0.03)*	0.080 (0.03)*
RGDP growth	0.188 (0.02)*	0.031 (0.02)	0.234 (0.03)*	−0.021 (0.03)
R^2	0.391	0.115	0.485	0.339
N	1296	1296	1296	1296

The dependent variables in the first two result columns are annual changes in the employment population ratios (EPR) and labor force participation rates (LFPR) of 48 contiguous states for the period 1988–2014. The dependent variables in the last two columns are annual growth rates in employment (E) and labor force (LF) of 48 contiguous states for the period 1988–2014. Independent variables are state real GDP growth rates, spatially weighted GDP (WGDP) growth rates of the neighboring states and rest of the 48US states GDP (RGDP) growth rates. Regressions include state level fixed effects. Panel corrected standard errors with cross section weights are reported in the parentheses

* Parameter estimates are statistically significant at 5% level of significance

regional migration plays a limited role in the short-run in adjusting to demand shocks. So, the possibility of the results being driven by employment data rather than labor force changes cannot be ruled out.

We use two sets of employment variables as dependent variables; change in employment—population ratio and employment growth. Similarly, we also use two labor force variables as dependent variables; change in labor force population ratio (or change in labor force participation rate) and labor force growth rate. For each dependent variable, we estimate Eq. (2) with state fixed effects. The sample is from 1988 to 2014 and comparable to the results in the first column of Table 2.

The estimates are in Table 3. In the first two columns, we present the employment population ratio and the labor force participation rate results. The results on employment population ratio data follow the same pattern as the Okun's law results with strong spatial factors emphasized by Molho (1995), Fogli et al. (2013). The employment population ratio change is more than four times bigger when state growth is associated with regional and national growth than when it is not. In the labor force participation rate results, we do not see the pattern expected if high labor mobility had been the driving force for the Okun's law results. Beyond the state fixed effects that should account for the long term labor force changes, we expected a high coefficient for the state GDP growth effects (if labor force in-migration is the dominant factor) followed by negative coefficients for WGDP and RGDP growths (if labor force out-migration is the dominant factor). The estimated coefficients are positive throughout.

In the next two columns, we present the results for the employment growth and labor force growth. We still see high employment growth when state GDP growth is associated with WGDP and RGDP growth. In the labor force growth estimates we still do not see any negative coefficient associated with WGDP, and a small, negative but statistically insignificant, coefficient on RGDP growth. Overall, the results indicate that the Okun's law results are driven primarily by employment changes and not by the labor force changes due to labor migration. The results also support Partridge and

Rickman (2006) results stressing the limited role of labor mobility in the short run in adjusting to regional shocks.

5 Conclusion

In this study, we estimate the state-level Okun's law after accounting for spatial GDP spillovers. The estimates show that state-specific growth has a small effect on state unemployment rate changes. State growths that are associated with regional and national growths have much bigger effect on state unemployment rates. Our analysis of employment and labor force data suggests that the above outcomes are primarily driven by employment changes and are not due to labor force changes. The results imply that coordination of macroeconomic policies between the states is important for regional labor markets.

References

Adanu, K.: A cross-province comparison of Okun's coefficient for Canada. Appl. Econ. **37**(5), 561–570 (2005)

Attfield, C.L.E., Silverstone, B.: Okun's coefficient: a comment. Rev. Econ. Stat. **79**, 326–329 (1997)

Blackley, P.: The measurement and determination of Okun's Law: evidence from state economies. J. Macroecon. **43**, 641–656 (1991)

Blanchard, O., Katz, L.: Regional evolutions. Brook. Pap. Econ. Act. **1**, 1–61 (1992)

Carlino, G., Inman, R.P.: Local deficits and local jobs: can US states stabilize their own economies? J. Monet. Econ. **60**(5), 517–530 (2013)

Christopoulos, D.K.: The relationship between output and unemployment: evidence from Greek regions. Pap. Reg. Sci. **83**, 611–620 (2004)

Fogli, A., Hill, E., Perri, F.: The Geography of the Great Recession. In NBER International Seminar on Macroeconomics, Vol. 9, No. 1, pp. 305–331. University of Chicago Press, (2013)

Freeman, D.: Regional tests of Okun's Law. Int. Adv. Econ. Res. **6**, 557–570 (2000)

Gordon, R.: Unemployment and potential output in the 1980s. Brook. Pap. Econ. Act. **2**, 537–564 (1984)

Guisinger, A. Y., Hernandez-Murillo, R., Owyang, M.T., Sinclair, T. M. (2015). A State-Level Analysis of Okun's Law. Federal Reserve Bank of Cleveland, Working Paper No. 15–23

Kuscevic, C.M.: Okun's law and urban spillovers in US unemployment. Ann. Reg. Sci. **53**(3), 719–730 (2014)

LeSage, J., Pace, K.: Introduction to Spatial Econometrics. Taylor & Francis Group, London (2009)

Molho, I.: Spatial autocorrelation in British unemployment. J. Reg. Sci. **35**, 641–658 (1995)

Okun, A.: Potential GNP: Its Measurement and Significance. American Statistical Association, Proceedings of the Business and Economics Statistics Section (1962)

Partridge, M.D., Rickman, D.S.: Fluctuations in aggregate U.S. migration flows and regional labor market flexibility. South. Econ. J. **72**, 958–980 (2006)

Prachowny, M.: Okun's law: theoretical foundations and revised estimates. Rev. Econ. Stat. **75**, 331–336 (1993)

Villeverde, J., Maza, A.: The robustness of Okun's law in Spain, 1980–2004 regional evidence. J. Policy Model. **31**, 289–297 (2009)

Yazgan, M., Yilmazkuday, H.: Okun's convergence within the U.S. Lett. Spat. Res. Sci. **2**, 109–122 (2009)