Okun's Law and Regional Spillovers: 
Evidence from Virginia Metropolitan Statistical Areas

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Abstract
The purpose of this paper is to examine the strength of the relationship between unemployment and GDP, the importance of regional spillovers and to determine the extent to which this relationship has been stable in Virginia metropolitan statistical areas (MSA) during the Great Recession. Our results indicate a substantially weaker relationship between unemployment and GDP in Virginia than that estimated for the U.S. economy and suggest that regional spillovers are very important in local labor markets and in defining the relationship observed at the national level. The MSA level data further supports asymmetries in Okun's law. the weaker relationship between GDP and unemployment at the local level suggests that while federal fiscal and monetary policies to stimulate aggregate demand during periods of economic recovery may be effective, over time, in reducing the unemployment rate, local economic development policies are not effective in achieving the substantial short term reduction in unemployment needed during recovery. The strong business cycle effects observed in a state like Virginia, relative to the U.S., suggests that countercyclical policies are fundamentally important and should be targeted more generally to exploit regional spillovers.

Keywords: Okun's law, the Great Recession, Regional Spillovers, Virginia
JEL Classification: C23, E24, E32, J01, R12

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1 Introduction

In the wake of the Great Recession, unemployment persists as a significant problem despite moderate growth in economic activity. This apparent disconnect between economic growth and unemployment is particularly concerning, especially in the context of efforts to formulate policies, at both the national and local levels, to promote economic growth to address labor market concerns.

Okun's (1962) estimate of the relationship between economic growth and the unemployment rate is consistently employed by policy makers and in forecasting. The stability of Okun's law through time, however, has been a source of concern [see Weber (1995), Moosa (1997), Silvapulle et al. (2004), Holmes and Silverstone (2006), Knotek (2007), and Ball et al. (2013)]. This concern is particularly apparent in the context of the weak labor market performance since the onset of the Great Recession [see Ball and Koenig (2009) and Owyang and Sekhposyan (2012)] and other jobless recoveries [see Holmes and Silverstone (2006)].

The empirical evidence suggests that the relationship between unemployment and output growth is stronger during periods of economic contraction [see Cuaresma (2003), Silvapulle et al. (2004), Holmes and Silverstone (2006), and Owyang and Sekhposyan (2012)]. We extend these analyses to assess the degree to which asymmetries in Okun's law are a feature of local economies and the extent to which the strength of these effects mirrors that for the U.S.

Regional estimates of the relationship between economic growth and unemployment in the U.S. tend to find that state level results are generally consistent with national estimates, though they tend to shower a greater degree of variability [see Blackley (1991) and Freeman (2001)]. Yazgan and Yilmazkuday (2009) present evidence of convergence across states centered on geographic clusters highlighting the importance of regional forces in local labor markets.
International analyses conducted suggest a weaker relationship at the regional level [see, for example, Apergis and Rezitis (2003), Christopoulos (2004), Villaverde and Maza (2009), Perugini (2009), Kangasharju et al. (2012), Binet and Facchini (2013) and Obert and Oelgemoller (2013)]. In this paper, we estimate a Panel Spatial Durbin Model to account for spatial dependency and estimate the importance of regional spillovers in local labor markets. Kuscevic (2012) examine Okun's law in U.S. MSA accounting for spatial dependence by specifying the Panel Spatial Durbin Model, yet without considering possible asymmetries during the Great Recession. Obert and Oelgemoller (2013) estimate the relationship between output and unemployment in German regions in this framework but focus primarily on within region effects rather than indirect spillover effects. Our primary focus is on evaluating the strength of Okun's law at the regional level and the importance of regional spillovers in local labor markets.

We focus our analysis on Virginia Metropolitan Statistical Areas (MSA). These are Blacksburg-Christiansburg-Radford, Charlottesville, Danville, Harrisonburg, Lynchburg, Richmond, Roanoke, Virginia Beach-Norfolk-Newport News (VA-NC), Washington-Arlington-Alexandria (DC-VA-MD-WV), and Winchester (VA-WV). These include MSAs that are not entirely located in Virginia but play an important role in the Virginia economy. In 2011, the MSAs covered nearly 90% of the civilian labor force and employment in Virginia and 82.7% of the unemployed. During 2009, Virginia had among the lowest unemployment rates in the country and a relatively stronger rate of GDP growth. Our analysis also includes the Washington D.C. metropolitan area which saw very severe unemployment despite marginally better economic conditions than most areas. These characteristics of Virginia make understanding the relationship between GDP growth and unemployment here particularly appealing.
2 Data and Preliminary Analysis

We estimate the relationship between the unemployment rate and the growth rate of GDP in Virginia MSAs using a balanced panel of annual observations on ten MSAs in Virginia between 2001 and 2011. Because we are using the changes in the unemployment rate and the growth rate of GDP this provides us with 100 observations. Data on GDP by metropolitan area are from the Bureau of Economic Analysis and data on the unemployment rate are from the Bureau of Labor Statistics.

Preliminary analysis of the data is conducted to assess their stability. This is important both conceptually and methodologically. First, a potential source of persistently high unemployment rates in the wake of the Great Recession is hysteresis. If the natural rate of unemployment depends on aggregate demand, that is, if an increase in cyclical unemployment produces a structural increase in the natural rate of unemployment, unemployment hysteresis can contribute towards positive feedbacks that may potentially push up the unemployment rate. Hysteresis in unemployment is defined by the notion that the equilibrium unemployment rate depends on the history of the actual unemployment rate (Blanchard and Summers, 1986). Testing for a linear form of hysteresis in unemployment involves testing for a unit root in the unemployment rate series (Cuestas and Gil-Alana, 2011). Second, analyses of two I(1) series may lead to spurious correlation among them and the potential need to account for a cointegrating relationship among the variables.

Table 1 presents panel unit root tests results for unemployment and GDP. The Im, Pesaran and Shin (2003) panel unit root test is computed from the individual Augmented Dickey Fuller unit root test statistic for each series. We also conduct a Fisher type test based on the p-values from the individual Augmented Dickey Fuller unit root test statistics. The number of lags
selected is based on the Bayesian Information Criteria. The data are cross-sectionally demeaned to control for cross sectional dependence.

The presence of a structural break reduces the power of the unit root tests (Perron, 1989). Our approach to testing for a unit root in the panel is based on a modification of the Fisher type test which allows for a deterministic break in 2009. We compute p-values for the MSA specific unit root tests with an exogenous break given in 2009 by simulation methods. We generate $N = 10$ iid $N(0,1)$ random variables and compute the partial sums indicative of a random walk process defined under the null hypothesis. We then estimate $\Delta ur_t = \gamma_1 ur_{t-1} + \gamma_2 \Delta ur_{t-1} + \alpha_0 + \gamma_3 \delta_{09}$, where $\delta_{09} = 1$ for years strictly greater than 2008 and obtain the test statistics for the null hypothesis $\gamma_1 = 0$. We repeat this process 10,000 times define the p-value from the sorted vector of replicated statistics. The p-values for the individual series are combined in the test statistic, $-2 \sum_{i=1}^{N} \ln p$ which is distributed as a $\chi^2_{2N}$ random variable. Note that this approach differs from that in Perron (1989) due to the fact that the unemployment rate is not a trending process and we therefore omit the deterministic trend.

We further conduct individual Zivot-Andrews tests for each MSA to allow for endogenously determined break points. For each series, 2009 was selected as the point of the break. We determine the empirical small sample p-values based on simulation methods to construct a fisher type test statistic for the null of a unit root.

The results suggest that the unemployment rate is stationary around a break in 2009 and that the growth rate of GDP is stationary around a constant. This suggest that hysteresis in unemployment is not supported in Virginia MSA and we proceed to examine the potential for asymmetries in Okun's law.
Table 1 Panel Unit Root Tests for Unemployment and GDP

<table>
<thead>
<tr>
<th></th>
<th>Unemployment Rate with a Break (Zivot Andrews)</th>
<th>Unemployment Rate with a Break (Fisher-type test based on Bai-Perron test)</th>
<th>Growth Rate of GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher test</td>
<td>-41.0584 (0.0037)</td>
<td>108.9636 (.0000)</td>
<td>31.0695 (.0543)</td>
</tr>
<tr>
<td>Im, Pesaran and Shin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>-</td>
<td></td>
<td>-2.166</td>
</tr>
<tr>
<td>W</td>
<td>-</td>
<td></td>
<td>-1.914 (.0280)</td>
</tr>
<tr>
<td>Blacksburg-Christiansburg-Radford</td>
<td>-7.7680 (0.1067)</td>
<td>-8.1333 (0.0034)</td>
<td>-1.5153 (.3914)</td>
</tr>
<tr>
<td>Charlottesville</td>
<td>-7.2932 (0.1256)</td>
<td>-7.3461 (0.0042)</td>
<td>-2.0848 (.2298)</td>
</tr>
<tr>
<td>Danville</td>
<td>-8.6601 (0.0787)</td>
<td>-9.3535 (0.0021)</td>
<td>-2.8713 (.1080)</td>
</tr>
<tr>
<td>Harrisonburg</td>
<td>-6.4762 (0.1667)</td>
<td>-7.0669 (0.0050)</td>
<td>-1.6519 (.3468)</td>
</tr>
<tr>
<td>Lynchburg</td>
<td>-7.4925 (0.1175)</td>
<td>-6.6587 (0.0069)</td>
<td>-2.3054 (.1847)</td>
</tr>
<tr>
<td>Richmond</td>
<td>-7.6962 (0.1094)</td>
<td>-8.4663 (0.0028)</td>
<td>-2.720 (.1241)</td>
</tr>
<tr>
<td>Roanoke</td>
<td>-8.1193 (0.0948)</td>
<td>-8.5235 (0.0028)</td>
<td>-2.0015 (.2495)</td>
</tr>
<tr>
<td>Virginia Beach-Norfolk-Newport News</td>
<td>-5.7227 (0.2240)</td>
<td>-6.3605 (0.0086)</td>
<td>-1.5856 (.3682)</td>
</tr>
<tr>
<td>Washington-Arlington-Alexandria</td>
<td>-6.7063 (0.1531)</td>
<td>-6.6767 (0.0068)</td>
<td>-2.2068 (.2031)</td>
</tr>
<tr>
<td>Winchester</td>
<td>-6.4925 (0.1654)</td>
<td>-7.2218 (0.0046)</td>
<td>-2.7171 (.1244)</td>
</tr>
<tr>
<td>Deterministic</td>
<td>Constant and Trend</td>
<td>Constant, break in 2009</td>
<td>Constant</td>
</tr>
<tr>
<td>Lags</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Author's Calculations; Note: p-values in parentheses for the null of a unit root. Asymptotic Critical Values for Zivot Andrews Unit Root Test: 1%: -5.43, 5% -4.80.

3 Methodology

Our methodological framework is based on the general model

\[ \Delta u_{it} = \rho \sum_j w_{ij} \Delta u_{jt} + \beta g_{yt} + \theta \sum_j w_{ij} g_{yt} + \varphi \delta_{09} g_{yt} + a_i + v_{it} \]

Where \( \Delta u_{it} \) is the change in the unemployment rate, \( g_{yt} \) is the growth rate of GDP, \( \delta_{09} \) is an indicator variable for the Great Recession in 2009, \( a_i \) are MSA specific fixed effects and \( v_{it} \) is the error term. The \( \sum_j w_{ij} \Delta u_{jt} \) and \( \sum_j w_{ij} g_{yt} \) terms correspond to distance weighted sums for the respective macroeconomic variables in other regions. The \( w_{ij} \) correspond to elements of the distance weighting matrix, \( W \). The distance matrix has zeros along the diagonals and is normalized such that the row sums are equal to one. The weights are computed as the inverse of the distance squared.
Model (1) collapses to the standard representation of Okun's law in first differences where \( \rho = \theta = \varphi = 0 \), that is, where the regional spillovers and asymmetries during the recession are not significant. The model collapses to an asymmetric representation of Okun's law with \( \rho = \theta = 0 \), that is, absent regional spillovers.

### 3.1 Asymmetries in Okun's Law

This general model provides the framework for evaluating asymmetries in Okun's law as well as the importance of regional spillovers in local labor markets. By imposing the assumption that the regional spillovers are zero, \( (\rho = \theta = 0) \), we obtain the standard static model with asymmetries. This allows us to evaluate the importance of asymmetries in Okun's law through the parameter \( \varphi \) and to examine the influence of omitting the spillovers from the analysis.

\[
\Delta u_{lt} = \beta g y_{lt} + \varphi \delta_{09} g y_{lt} + a_{l} + v_{lt}
\]

The coefficient \( \beta \) corresponds to Okun's coefficient during periods of expansion between 2002 and 2008 and 2010, 2011, \( \beta + \varphi \) is the corresponding estimate for Okun's coefficient during the Great Recession. Time effects for the remaining periods were found to be insignificant; this includes 2010, a year which for many has raised the specter of a breakdown in Okun's law following the Great Recession.

We focused on latter part of the Great Recession, occurring in 2009, as opposed to examining periods during which the output gap is negative, as is usual in the literature, or the entire recession. The reason for this is that explanations regarding the potential sources for asymmetries in Okun's law, including pessimistic personnel policies, inventory and idle capacity and job matching theories, are rather consistent with a stronger relationship during the onset of the contraction. In 2009, this coincided with substantial cash-flow constraints induced by the absence of liquidity in labor markets that may have contributed towards reductions in payrolls.
The break in 2009 alone is consistent with the fact that we observe no significant change in the slope coefficient in 2008. The break in the coefficient measuring change in the slope during the downturn is not the same in 2008 and in 2009 – that is the difference between the two periods is 0.556 with a standard error of 0.128 suggesting that indeed the difference in Okun's coefficient between the two is statistically significant. Similarly, the difference in the Okun's law coefficient between 2008 and the rest of the sample period is not statistically significant.

3.2 Panel Serial Correlation

The Wooldridge test for autocorrelation in panel data yields a p-value of 0.0002 which suggests that we reject the null of no first-order serial correlation. We therefore consider generalized least squares estimates for the regression model that allow for first order serial correlation as well as iterated generalized least squares estimates with panel AR(1) serial correlation. The former considers quasi-differenced data based on estimates for the strength of the AR(1) serial correlation. The latter considers MSA specific AR(1) correlated errors. Both are estimators correct for serial correlation and allow for testing for asymmetries in Okun law by testing the hypothesis that $\phi = 0$. These estimates are asymptotically efficient.

3.3 Regional spillovers

The presence of important regional spillovers suggests that correlation among the metropolitan areas may create problems in estimation. To address this issue, we add terms that correspond to the values for the change in the unemployment rate and GDP growth in neighboring areas and estimate the model by maximum likelihood.

The addition of the spatially lagged growth rate of GDP is natural in defining regional spillovers in Okun's law. In well integrated labor markets, the growth rate of GDP in neighboring regions affects the unemployment rate in the local area. The addition of the spatially lagged
unemployment rate is based on the fact that individuals within a particular MSA, who are therefore counted among the unemployed in that region, may not work in the metropolitan area. As unemployment growth here will affect both individual income and GDP growth in regions between and in neighboring MSA, this can influence the demand for goods and production, and therefore the unemployment rate, in neighboring areas. In this way spatial autocorrelation becomes important. Failure to account for spillovers of this nature may lead to biased estimates. The empirical evidence suggests that the influence of regional spillovers did not increase significantly during the Great Recession and is therefore not included in our model.

The regional spillovers generate feedbacks among the MSA that will define the ultimate effect of a change in the growth rate of output on the unemployment rate. The strength of the ultimate resolution of the regional feedbacks depends on proximity and is therefore MSA specific. LeSage and Pace (2009) and Debarsy et al. (2011) define the direct effects as the partial derivatives for a change in the explanatory variables in a particular spatial unit on the dependent variable of all other units measured by the average of the diagonal elements of the matrix S.

\[
S(W) = (I - \rho W)^{-1}(I\beta + W\theta)
\]

As such, to define the direct effects of changes in the growth rate of GDP we average these effects over each of the MSA. This measures the change in the unemployment rate in a particular region due to a change in the growth rate of GDP in the region, once the spillovers have been accounted for. The indirect effects measure the average effects, across all MSA, of changes in the growth rate of output in other regions on unemployment in a particular region. The total effects are then the sum of these two effects and measure the change in unemployment in a region due to a change in the growth rate of output in all regions.
4 Empirical Results

4.4 Okun's Law

Table 2 presents the estimates for Okun's Law coefficient using the first difference specification stated above. The coefficient estimate for the whole sample, resulting from the assumption of an absence in a break in the coefficient, \( \varphi = 0 \), implies that a percentage point increase in GDP growth reduces unemployment by 0.19 percentage points.

Our estimate for the Okun coefficient is substantially smaller than the central estimate of 0.3, a finding that is consistent with the international evidence that the relationship between unemployment and GDP is weaker at the sub-national levels. This weaker relationship at the MSA level may be due to a variety of factors, chief among which is the possibility that increased labor mobility both within and between MSA may contribute to smaller changes in unemployment as a result of cyclical economic shocks. The greater degree of labor mobility, coupled with agglomeration effects, may help to detach local labor markets from local economic conditions. These labor flows have the potential to negate some of the effect of labor market shocks (Moretti, 2011). Larger variations in productivity among localities may further contribute towards explaining greater asymmetries and a weaker relationship at the state level.

4.5 Asymmetries in Okun's Law

Table 2 further presents estimates for Okun's law in Virginia, allowing for a break in the slope coefficient in 2009 consistent with asymmetries in Okun's law. The resulting break in the coefficient estimate is highly significant. The results suggest that the relationship between unemployment and GDP increased in strength during the recession.

During the last decade, for periods of economic growth in VA, the estimated coefficient is -0.10 and during the recession the estimated coefficient is -0.67 with 95% confidence interval
around the sum $\beta + \varphi$ given by $[-0.82,-0.51]$. This suggests an additional 0.57 percentage point increase in the unemployment rate for every percentage point loss in GDP during the recession.

The estimated asymmetries show a larger difference between periods of expansion and contraction than that estimated for the U.S. economy. Cuaresma (2003) estimates a coefficient of -0.19 for expansions and -0.44 for contractions. Silvapulle et al. (2004) estimates Okun coefficients of -0.25 and -0.61 with respect to increases and decreases in cyclical output. Owyang and Sekhposyan (2012) estimate a difference of 0.20 during the Great Recession, a difference nearly double that of other recessions. Pereira (2013) estimates Okun's coefficient for the U.S. of -0.42 during periods of expansion and -0.55 during periods of contraction and finds no significant difference between the Great Recession and other recessions in the post-war with respect to Okun's law.

<table>
<thead>
<tr>
<th>Table 2 Okun's Law during the Great Recession</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Okun's Law Coefficient</td>
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<tr>
<td></td>
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<tr>
<td>Expansions</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Great Recession</td>
</tr>
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<td></td>
</tr>
</tbody>
</table>

95% Confidence Intervals Given in Parentheses
4.6 Regional Spillovers

Regional spillovers are important local determinants for the unemployment rate. It is these regional spillovers that tie together estimates for Okun's law at the local and national levels. The estimate for Okun's law for the direct effects of output growth on unemployment within the MSA is -0.07, nearly a third of that found when spillovers are not accounted for. Regional spillovers are fairly large and responsible for more than eighty percent of the total change in the unemployment rate. An increase in neighboring MSA output growth reduce local unemployment by -0.31 percentage points. The combined effect of local and regional growth on local area unemployment is -0.38, quite similar to that obtained at the national level.

The asymmetries in the relationship between the change in the unemployment rate and output growth are also driven by regional spillovers. During periods of expansion, local economic growth reduces the unemployment rate by only 0.04 percentage points. During the Great Recession, however, the increase in the unemployment rate was 0.21 percentage points larger for a total effect of a 0.25 percentage point increase in the unemployment rate for a one percentage point reduction in the local growth rate of economic activity. The influence of growth in neighboring regions, however, is substantially larger and the asymmetries in the relationship are nearly three times as strong.

The total effect of an increase in the growth rate of economic activity in all regions in a single MSA mirrors those effects found for Okun's law at the national level. During periods of expansion a one percentage point increase in the growth rate of economic activity reduces the unemployment rate by 0.21 percentage points. In 2009, during the Great Recession, a one percentage point reduction in the growth rate of economic activity across all Virginia MSA increased the unemployment rate, on average, by just more than one percentage point. The
Table 3 Estimates for the Direct and Indirect Effects from the Spatial Durbin Model

<table>
<thead>
<tr>
<th></th>
<th>Symmetric</th>
<th>Asymmetric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$MSA \ GDP$</td>
<td>-0.380*</td>
<td>-0.211*</td>
</tr>
<tr>
<td></td>
<td>(0.157)</td>
<td>(0.0683)</td>
</tr>
<tr>
<td>$\delta_{09}MSA \ GDP$</td>
<td>-0.825*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.306)</td>
<td></td>
</tr>
<tr>
<td><strong>Direct</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$MSA \ GDP$</td>
<td>-0.0680**</td>
<td>-0.0387*</td>
</tr>
<tr>
<td></td>
<td>(0.0203)</td>
<td>(0.0142)</td>
</tr>
<tr>
<td>$\delta_{09}MSA \ GDP$</td>
<td>-0.208*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0780)</td>
<td></td>
</tr>
<tr>
<td><strong>Indirect</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$MSA \ GDP$</td>
<td>-0.312*</td>
<td>-0.172*</td>
</tr>
<tr>
<td></td>
<td>(0.138)</td>
<td>(0.0570)</td>
</tr>
<tr>
<td>$\delta_{09}MSA \ GDP$</td>
<td>-0.617*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.232)</td>
<td></td>
</tr>
</tbody>
</table>

Robust Standard errors in parentheses; **p<0.05, *p<0.1

asymmetries are naturally very large although the national estimates are within the margin of error for the estimated effect.

5 Conclusions and Policy Implications

The purpose of this paper is to examine the strength of the relationship between unemployment and GDP at the MSA level and to determine the extent to which this relationship has been stable in Virginia through the Great Recession. Our results indicate a substantially weaker relationship between unemployment and GDP in Virginia than that estimated for the U.S. economy and supports asymmetries in Okun's law. Our results further highlight the importance of regional spillovers in well integrated product and labor markets. Indeed, fairly substantial spillovers among regions may translate the national and state level output effects to local labor markets.
These results have several important implications for policy. First, the weaker relationship between GDP and unemployment at the local level suggests that while federal fiscal and monetary policies to stimulate aggregate demand during periods of economic recovery may be effective, over time, in reducing the unemployment rate, local economic development policies are not effective in achieving the substantial short term reduction in unemployment needed during recovery. These results are consistent with those found in the literature regarding the effectiveness of state and local economic stabilization policies [see, for example, Hanson and Rohlin, (2013)]. In general, the effects of local policies are weak and stabilization policies are better addressed at the federal level [see, for example, Oates (1972), and Carlino and Inman (2013)]. This is particularly important due to the large role that regional spillovers play in local labor markets.

Second, the asymmetries in Okun's law across the business cycle have implications for both the nature and the timing of policies to improve labor market outcomes. The presence of asymmetries in Okun's law suggests that, during a weak recovery, the increase in economic growth required to recover the jobs lost during the recession may be substantial. The magnitudes involved here are especially aggravated by the presence of asymmetries across the business cycle. The strong business cycle effects observed in a state like Virginia, relative to the U.S., suggests that countercyclical policies are fundamentally important and should be targeted more generally to exploit regional spillovers.
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