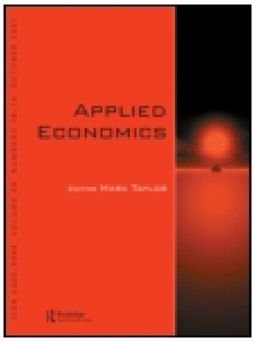

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This article contributes to the empirical literature of Okun's law in three respects. First, in contrast to the limited data used in the existing studies, we employ two extensive (across countries and across states, i.e. within a country) panel data sets to investigate the validity of Okun's law. Second, the use of the Pooled Mean Group (PMG) estimator permits us not to pre-filter the data as often done in the current literature, and can take into account the possibility of cointegration between unemployment and output. Third, in addition to the short-run relationship or cyclical components between unemployment and output, we also estimate the long-run linkage between these two important variables. Empirical results show that unemployment and output are long-run cointegrated, irrespective of using country- or state-level data. Moreover, the unemployment-output linkages are found to be negative and highly significant both in the short- and long-run. Our results not only confirm the validity of Okun's law (in the short-run) but also point out that a similar tradeoff exists in the long run.

Keywords: Okun's law; panel data; pooled mean group estimator

JEL Classification: C23; E24

I. Introduction

Ever since the postulation of Okun (1962), the inverse linkage between cyclical movements in unemployment and output has been widely accepted as an empirical regularity in the macroeconomic literature. Reasons for this negative relationship include induced adaptation in labour force participation, working hours and productivity (e.g. Holmes and Silverstone, 2006). The relationship, known as Okun's law, has played an important role in conventional macroeconomic modelling as pointed out by Sögner and Stiassny (2002). First, this empirical linkage, when combined with the Phillips curve, can be used to obtain the aggregate supply function. Second, it can also serve as a criterion for the authority to appraise the cost of higher unemployment rates in terms of output growth (the sacrifice ratio). Third, the effectiveness of disinflation policy relies on how much the unemployment rate responds to the output growth rate. Finally, as argued in Perman and Tavera (2005, 2007), whether or not the Okun's coefficients converge is of main interest for groups of countries which are (likely to become) members of a monetary union e.g. Economic and Monetary Union (EMU) with common monetary policy shocks. Thus, a more thorough and complete

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analysis on Okun's relationship can shed some light on the decision making of policymakers.

The recent literature extends the standard linear specification commonly used to estimate Okun's law in many different respects. First, there are increasing papers examining whether the Okun's relationship is stable over time. For example, while Weber (1995) and Sögner (2001) find no evidence of structural changes, Moosa (1997), Lee (2000) and Huang and Chang (2005) provide strong evidence of structural breaks in the relationship between cyclical unemployment and output. Furthermore, Huang and Lin (2008) and Yazgan and Yilmazkuday (2009) show that there is an overwhelming evidence in support of time-varying Okun's coefficients. Second, there are also many studies investigating whether Okun's law is linear or nonlinear. Virén (2001) demonstrates that the Okun's curve is nonlinear, in that output growth has a larger impact on unemployment when unemployment is low and output is high, and vice versa. Crespo-Cuaresma (2003) utilizes a nonlinear threshold regression of Hansen (2000) to estimate the Okun's coefficients, and finds that the impact of cyclical output on cyclical unemployment is nonlinear and significantly larger in recessions than in expansions. In contrast, Huang and Lin (2006) implement the flexible nonlinear inference method of Hamilton (2001) to US data, and find substantial outcome of nonlinearity between cyclical components of unemployment and output.[1]

Third, there is a large literature considering asymmetry in the Okun's curve, i.e. same increases and decreases in output results in different changes in unemployment. According to Harris and Silverstone (2001) and Holmes and Silverstone (2006), the asymmetry in Okun's relationship can arise due to reasons like factor substitution, changes in sectoral growth rates and labour force participation, asymmetric adjustment costs between contracting and expanding firms, and the role of the mismatch. For instance, Silvapulle *et al.* (2004) find evidence in support of asymmetric Okun's relationship using post-war US data, i.e. the short-run impacts of positive cyclical output on cyclical unemployment are quantitatively distinct from those of negative ones. In particular, the results show that cyclical components of unemployment are more sensitive to negative cyclical components of output than to positive ones. Holmes and Silverstone (2006) employ a Markov switching model to allow for asymmetry between unemployment and output across regimes or asymmetry within a regime, and find that a significant inverse linkage between cyclical unemployment and output exists in U.S. expansionary regimes. Accordingly, they argue that the notion of jobless recoveries in the US is likely to be exaggerated.

This article intends to contribute to the Okun's literature in three ways. The first one is related to the issue of data coverage. To date, most extant studies of Okun's law either consider only one single particular country or utilize a limited number of regions or economies in the empirical analysis. For example, Crespo-Cuaresma (2003), Silvapulle *et al.* (2004), Holmes and Silverstone (2006) and Huang and Lin (2008) consider only one single country in their analysis. Furthermore, Lee (2000), Freeman (2001), Sögner and Stiassny (2002), Apergis and Rezitis (2003), Adanu (2005), Perman and Tavera (2005) and Villaverde and Maza (2009) provide results using more data on different regions or countries. In this respect, our first contribution in this article is to use two extensive (unbalanced) panel data, both across countries and across states (within a country), to re-examine Okun's law. The cross-country panel includes up to 53 countries over the 1980 to 2005 period (with a total of 1108 observations) and the cross-state panel contains 50 states of US over the period 1976 to 2006 (with a total of 1450 observations). In addition to the increase of the observations, hence the precision of estimates, the use of panel data also allows us to control for country-specific or state-specific effects, to mitigate omitted variables problem and to provide a more general and robust conclusion on the validity of Okun's law across broad cross-sections of countries and states.

The second, and the most important, one is concerned with the filtering techniques. Conventionally, the estimation of Okun's coefficients requires data on the cyclical components of unemployment and output. Almost every extant study relies either on various filtering techniques such as the Hodrick–Prescott filter (Hodrick and Prescott, 1997), band-pass filter (Baxter and King, 1999) or the structural time series approach (Harvey, 1989; Moosa, 1999), to name a few, to obtain transitory elements of unemployment and output. However, it is very likely that alternative filtering methods can generate distinct cyclical unemployment and output, result in dissimilar Okun's estimates, and reach different conclusions. Moreover, another popular first-difference approach might also provide incorrect estimate of Okun's coefficient if unemployment and output are cointegrated. In this respect, our second contribution is to implement the Pooled Mean Group (PMG) approach of Pesaran *et al.* (1999) to

[1] By allowing for both features, Huang and Chang (2005) implement a structural change with threshold approach to Canada data, and provide evidence supporting that the Okun's relationship is not only unstable but also nonlinear.

directly estimate the (Okun's) relationship of unemployment and output in the short run (or at the business cycle frequency). The novel approach does not require us to pre-filter the data, and, in the meantime, allows us to take into account the possible cointegration between unemployment and output.[2]

The third one is related to the long-run unemployment-output nexus. Although the link between unemployment and output has been extensively investigated in the business-cycle frequency (short-run), the long-run (cointegrated, long-run equilibrium) relationship between unemployment and output has not been examined in a systematic way. This long-run or equilibrium association may be of interest and importance to both academic researchers and policymakers. In this respect, note that the PMG approach not only provides estimates on the short-run coefficients but also offers estimates on the long-term coefficients between unemployment and output. Thus, as a byproduct, our third contribution is to investigate the long-run relationship between unemployment and output. We intend to shed some light on the following issues. Are unemployment and output cointegrated? Is there any tradeoff between unemployment and output in the long run (as in the short-run)?

By using the comprehensive panel data sets across countries and states, some interesting messages emerge. In the short run, the (average) Okun's coefficient for the country panel has an estimated value of −0.2015, which is negative as predicted by Okun (1962) and is highly significant at 1% level. In a similar way, that for the state panel has an Okun's estimate of −0.1544, which continues to be significantly negative at 1% level. Both results provide favourable evidence in support of Okun's law. In the long run, unemployment and output are cointegrated for both the across-country and within-country (state) panels. As such, empirical results from using the (first) differenced data can provide inappropriate, if not incorrect, conclusions. Finally, in line with the short-run results, we find that unemployment and output are also inversely related in the long run for both panels. These findings suggest that the negative unemployment-output tradeoff not only exists in the short term but also in the long term.

This article is organized as follows. In Section II, we briefly review the PMG approach. In Section III, we discuss the data sources. In Section IV, we provide empirical estimates using both cross-country and cross-state data. In Section V, we conclude this article.

II. Model and Methodology

There are many existing studies examining the validity of Okun's law and the magnitude of the Okun's coefficients using alternative econometric techniques and different samples. The main contribution of this article is to re-visit the issue in a heterogeneous panel Autoregressive Distributed Lag (ARDL) framework using the most comprehensive data across countries and states. The heterogeneous panel ARDL model is then estimated by the PMG approach (along with the mean group, or Mean Group (MG), estimator), proposed by Pesaran *et al.* (1999), and discussed right below. Pesaran *et al.* (1999) show that the PMG estimator possesses at least the following statistical advantages. First, it can be applied to either stationary or nonstationary regressors, so that no pre-testing of unit root is required. Second, it offers estimates on the long-run relationship as well as the short-term coefficients among variables of interest. Third, if the null hypothesis of long-run parameters homogeneity cannot be rejected, the PMG estimator is not only consistent but also more efficient than the MG counterpart.

In the time series framework, Pesaran and Shin (1999) and Pesaran *et al.* (2001) propose the autoregressive distributed lag models to estimate the long-run cointegrating relationship among variables of interest. In a panel data framework, suppose that the long-run relationship between unemployment (u_{it}) and output (y_{it}) is given by

$$u_{it} = \mu_i + \theta y_{it} + \epsilon_{it} \tag{1}$$

where μ_i is the fixed effects, $i = 1, 2, \ldots, N$, and $t = 1, 2, \ldots, T$. Further, Pesaran *et al.* (1999) suggest to nest Equation 1 in a general ARDL specification to allow for rich dynamics. For instance, the ARDL(p, q) model can be written as

$$u_{it} = \mu_i + \sum_{j=1}^{p} \lambda_{ij} u_{i,t-j} + \sum_{j=0}^{q} \delta_{ij} y_{i,t-j} + \epsilon_{it} \tag{2}$$

[2]Additional advantage of the PMG approach is that we do not need to pre-test the existence of (panel) unit roots. The methodology is equally applicable irrespective of stationary or nonstationary variables being used.

After re-parameterization, Equation 2 can be written as an error correction form,

$$\Delta u_{it} = \mu_i + \phi_i u_{i,t-1} + \beta_i y_{it} + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta u_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^* \Delta y_{i,t-j} + \epsilon_{it}$$

$$= \mu_i + \phi_i \left[u_{i,t-1} - \theta_i y_{it} \right] + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta u_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^* \Delta y_{i,t-j} + \epsilon_{it} \quad (3)$$

where $\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij})$, $\beta_i = \sum_{j=0}^{q} \delta_{ij}$, $\lambda_{ij}^* = -\sum_{m=j+1}^{p} \lambda_{im}$, $\delta_{ij}^* = -\sum_{m=j+1}^{q} \delta_{im}$, $j = 1, 2, \ldots, q-1$. While the coefficient $\theta_i = -\beta_i/\phi_i$ defines the long-run or equilibrium relationship between u_{it} and y_{it}, the short-run coefficient related u_{it} to y_{it} is defined by δ_{ij}^*. Moreover, ϕ_i measures the speed of adjustment of u_{it} toward its long-run equilibrium following a given change in y_{it}, and $\phi_i < 0$ ensures that such a long-run relationship exists. Accordingly, discovery of a significantly negative ϕ can be treated as evidence supporting cointegration between u_{it} and y_{it}.

In the literature, there are alternative procedures for estimating the model. Among which, Pesaran and Smith (1995) suggest to use the MG estimator, which imposes no cross-country coefficients constraints and can be estimated on a country-by-country basis. In contrast, Pesaran *et al.* (1999) propose the PMG estimator, which restricts the long-run parameters to be identical over the cross section, but allows the intercepts, short-run coefficients (including the speed of adjustment) and error variances to differ across groups on the cross section. If the long-run homogeneity restrictions are valid, Pesaran *et al.* (1999) have shown that the maximum likelihood-based PMG approach will yield a more efficient estimator than the MG counterpart. Particularly, Pesaran *et al.* (1999) propose a standard Hausman-type statistic to test for the validity of a cross-sectional, long-run homogeneity restriction of the form $\theta_i = \theta$, $i = 1, 2, \ldots, N$ – and hence the suitability of the PMG estimator.

III. Data Sources

In this study, we use two large panels of cross-country and cross-state data sets. The cross-country data on unemployment rate and (the logarithm of) output (real gross domestic product) come from the World Bank Indicators, World Bank. The sample consists of 53 countries with annual data during the period 1980 to 2005. Thus, the country panel consists of a total of 1108 yearly observations. Given the PMG procedure's requirements on the (long-run) time-series dimension of the data, we include only countries that have at least 15 consecutive observations.[3] In addition, we also assess whether the unemployment-output nexus varies between Organization for Economic Co-operation and Development (OECD) versus non-OECD subsamples. See Table 1 for the list of 53 countries included in the sample.

In contrast, the cross-state panel contains yearly data on 50 states of US over the period 1976 to 2006, with a total of 1450 annual observations. The data on unemployment rates are downloaded from Econmagic while the data on output, proxied by the Gross Domestic Product (GDP) by state, are from Bureau of Economic Analysis. Table 2 provides the whole list of 50 states contained in the sample. In addition, we classify the 50 states into eight regions to assess if our results are robust to alternative subsamples.

IV. Empirical Results

Cross-country results

Table 3 reports the main results on the estimates of both long- and short-run parameters linking unemployment rate and real GDP (output) using cross-country panel data. In particular, we experiment four different sets of sample. The full sample (Full) consists of all 53 countries, and the restricted sample (Restricted) consists of 32 countries after deleting the countries with interpolated data. Moreover, all the countries are also classified into OECD (21 countries) and Non-OECD (32 countries) subsamples. While the lag order of the ARDL in Equation 2 is chosen to be (2, 1), the main findings (not reported) continue to hold when we consider alternative combinations of lag orders up to (3, 3). Furthermore, despite that we have implemented two distinct estimators (PMG and MG), only the results obtained by the PMG estimator are reported due to its gain in consistency and efficiency over other panel estimators (MG). In fact, in every case, the Hausman test of the null hypothesis of identical long-run parameters cannot be rejected at any conventional

[3]However, for some countries, there are some missing data (gaps) between different time periods. In this case, we use the interpolation method to fill the 'gap'. In the robustness check, we drop these countries to see if the main results are altered.

Table 1. List of 53 countries

Country	Restricted	OECD	Country	Restricted	OECD
Argentina	X	–	Luxembourg	X	X
Australia	X	X	Macao, China	X	–
Austria	X	X	Malaysia	–	–
Bahamas, The	–	–	Mexico	–	–
Belgium	X	X	Morocco	–	–
Brazil	–	–	The Netherlands	X	X
Canada	X	X	New Zealand	X	X
Chile	X	–	Nicaragua	–	–
China	X	–	Norway	X	X
Colombia	–	–	Pakistan	–	–
Costa Rica	–	–	Panama	–	–
Denmark	X	X	Paraguay	–	–
Ecuador	X	–	Peru	–	–
Egypt, Arab Rep.	–	–	Philippines	X	–
El Salvador	–	–	Portugal	X	X
Estonia	X	–	Singapore	X	–
Finland	X	X	Spain	X	X
France	X	X	Sri Lanka	–	–
Greece	X	X	Sweden	X	X
Honduras	–	–	Thailand	–	–
Hong Kong, China	X	–	Trinidad and Tobago	X	–
Ireland	–	X	Turkey	–	–
Israel	X	–	United Kingdom	X	X
Italy	X	X	United States	X	X
Jamaica	–	–	Uruguay	–	–
Japan	X	X	Venezuela, RB	X	–
Korea, Rep.	X	X			

Notes: 'Restricted' denotes the restricted sample, i.e. dropping countries from the full sample with some data being interpolated. 'OECD' indicates OECD countries, and the others are non-OECD countries.

Table 2. List of 50 states

State	Region	State	Region
Alabama	Southeast	Montana	Rocky Mountain
Alaska	Far West	Nebraska	Plains
Arizona	Southwest	Nevada	Far West
Arkansas	Southeast	New Hampshire	New England
California	Far West	New Jersey	Mideast
Colorado	Rocky Mountain	New Mexico	Southwest
Connecticut	New England	New York	Mideast
Delaware	Mideast	North Carolina	Southeast
Florida	Southeast	North Dakota	Plains
Georgia	Southeast	Ohio	Great Lakes
Hawaii	Far West	Oklahoma	Southwest
Idaho	Rocky Mountain	Oregon	Far West
Illinois	Great Lakes	Pennsylvania	Mideast
Indiana	Great Lakes	Rhode Island	New England
Iowa	Plains	South Carolina	Southeast
Kansas	Plains	South Dakota	Plains
Kentucky	Southeast	Tennessee	Southeast
Louisiana	Southeast	Texas	Southwest
Maine	New England	Utah	Rocky Mountain
Maryland	Mideast	Vermont	New England
Massachusetts	New England	Virginia	Southeast
Michigan	Great Lakes	Washington	Far West
Minnesota	Plains	West Virginia	Southeast
Mississippi	Southeast	Wisconsin	Great Lakes
Missouri	Plains	Wyoming	Rocky Mountain

Notes: The full sample consists of total 50 states in the US. There are eight subsamples (regions).

Table 3. Okun's law across countries

			Subsamples	
	Full (1)	Restricted (2)	OECD (3)	Non-OECD (4)
Long-run coefficient				
y_{it}	−0.0290***	−0.0321***	−0.0430***	0.0133***
	(0.0036)	(0.0047)	(0.0064)	(0.0021)
Error correction coefficient				
ϕ	−0.1648***	−0.1274***	−0.1197***	−0.2124***
	(0.0193)	(0.0220)	(0.0252)	(0.0270)
Short-run coefficient				
$\Delta u_{i,t-1}$	0.1702***	0.2118***	0.2692***	0.1035**
	(0.0366)	(0.0495)	(0.0459)	(0.0589)
$\Delta y_{i,t}$	−0.2015***	−0.2383***	−0.2731***	−0.1547***
	(0.0239)	(0.0344)	(0.0455)	(0.0214)
c	14.1367***	12.5049***	15.7362***	−4.8263***
	(1.5553)	(2.0336)	(3.0952)	(0.7103)
Number of countries	53	32	21	32
Number of observations	1108	681	457	651

Notes: The dependent variable is the unemployment rate u_{it}. The ARDL lag order is selected to be (2, 1). The full sample (Full) consists of all 53 countries, and the restricted sample (Restricted) consists of 32 countries by dropping the countries with some data interpolated. There are 21 OECD countries (OECD) and 32 non-OECD countries (Non-OECD) in the subsamples. Note that, although not reported, all the Hausman tests can not reject the null hypothesis of long-run parameter homogeneity. Thus, the PMG estimates are favoured and reported in this Table. The values in the parentheses are the corresponding SEs of the coefficient estimates.
*** and ** indicate significance at 1 and 5% levels, respectively.

significant levels and, thus, assures the adequacy of using the PMG approach.[4]

Starting with the estimates of the error correction coefficients ϕ, Table 3 reveals that the estimated coefficients are all negative and highly significant, regardless of samples used. As a result, the results provide overwhelming evidences in support of a long-run, cointegrating relationship between unemployment and output. From column (1) of Table 3, we find that the estimated long-run coefficient from the full sample is −0.0290 with SE being 0.0036. The estimate is significantly negative, indicating that the unemployment rate is inversely related to real output even in the long run. Particularly, the estimated coefficient implies that if a country increases its (logarithm of) real GDP by 1%, the unemployment rate will roughly decrease by 2.9 percentage points. In contrast, the long-run Okun's estimate for the restricted sample, displayed in column (2) of Table 3, is found to be −0.0321 (with SE being 0.0047), which is even larger in absolute magnitude (although not necessarily in a significant way) compared to the full sample estimate. In addition, by looking at the subsample results in columns (3) and (4) of Table 3, we find that, while the long-run linkage between unemployment and output for OECD countries remains negative (−0.0430) and statistically significant, that of the non-OECD countries appears to be significantly positive (0.0133). In other words, in the long term, there is a tradeoff between unemployment and output only for OECD economies but, in contrast, no such relationship is found for non-OECD economies.

On the other hand, since the PMG approach does not restrict the short-run coefficients to be identical across countries, a single pooled estimate for each coefficient is currently not available. However, we can still examine the average short-run effect by considering the mean of the corresponding coefficients across countries. In so doing, first, we find that the first-order autoregressive coefficients on the lagged unemployment rate are 0.1702 for the full sample, 0.2118 for the restricted sample, 0.2692 for the OECD subsample and 0.1035 for the non-OECD subsample, respectively. They are not only positive but also statistically significant at 5% level (or better), and indicate a slight to moderate persistence of the unemployment rate dynamics. More importantly, we find that the short-run average relationship between the unemployment rate and output, i.e. the conventional Okun's relationship appears to be strongly negative and, thus, is consistent with the traditional view that higher output

[4] For brevity, the results of Hausman tests and the outcomes obtained by the MG estimators are omitted, but available upon request.

Table 4. Okun's law across states

	Full (1)	Subsamples: New England (2)	Mideast (3)	Great Lakes (4)	Plains (5)	Southeast (6)	Southwest (7)	Rocky Mountain (8)	Far West (9)
Long-run coefficient									
y_{it}	−0.0299***	−0.0312***	−0.0362***	−0.0927***	−0.0270***	−0.0520***	−0.0079***	−0.0210***	−0.0252***
	(0.0016)	(0.0038)	(0.0050)	(0.0127)	(0.0052)	(0.0071)	(0.0030)	(0.0029)	(0.0030)
Error correction coefficient									
ϕ	−0.3588***	−0.4310***	−0.3631***	−0.2268***	−0.2912***	−0.2671***	−0.6918***	−0.5093***	−0.4154***
	(0.0139)	(0.0370)	(0.0436)	(0.0104)	(0.0177)	(0.0156)	(0.0653)	(0.0320)	(0.0380)
Short-run coefficient									
$\Delta u_{i,t-1}$	0.3895***	0.4477***	0.5320***	0.3304***	0.2987***	0.3733***	0.3248***	0.3802***	0.4243***
	(0.0231)	(0.0421)	(0.0546)	(0.0389)	(0.0562)	(0.0442)	(0.0799)	(0.0974)	(0.0654)
$\Delta y_{i,t}$	−0.1544***	−0.1778***	−0.1673***	−0.3200***	−0.1037***	−0.2044***	−0.1137***	−0.1319***	−0.3949***
	(0.0093)	(0.0101)	(0.0297)	(0.0362)	(0.0248)	(0.0211)	(0.0160)	(0.0219)	(0.1386)
c	15.0713***	17.3803***	19.0746***	28.5338***	10.3384***	18.7952***	11.5707***	14.6707***	15.4679***
	(0.6048)	(1.2222)	(2.8495)	(1.5240)	(0.9918)	(1.0475)	(0.9568)	(1.1396)	(1.9093)
Number of states	50	6	5	5	7	12	4	5	6
Number of observations	1450	174	145	145	203	348	116	145	174

Notes: The dependent variable is the unemployment rate u_{it}. The ARDL lag order is selected to be (2, 1). The full sample consists of all 50 US states, and the subsample consists of eight regions, i.e. New England, Mideast, Great Lakes, Plains, Southeast, Southwest, Rocky Mountain, and Far West. Note that, although not reported, all the Hausman tests cannot reject the null hypothesis of long-run parameter homogeneity. Thus, the PMG estimates are favoured and reported in this table. The values in the parentheses are the corresponding SEs of the coefficient estimates. Due to the re-definition of gross state product after 1997, we include a dummy variable to control for this effect. For brevity, the results on the dummy variable are omitted but available upon request.
***Indicates significance at 1% level.

is associated with lower unemployment (or vice versa). The estimated (standard, short-run) Okun's coefficients are −0.2015, −0.2383, −0.2731 and −0.1547, for the Full, Restricted, OECD and Non-OECD (sub)samples, respectively. All the coefficients are negative in nature and statistically significant at 1% level. As a consequence, the findings not only yield overwhelming and robust support of Okun's law across a large cross-section of countries but also provide an estimate more comparable in magnitude to those found in the current Okun's literature. Besides, two extra interesting findings emerge from the subsample results. First, the (absolute) magnitude of the short-run Okun's estimate is significantly larger for OECD economies than for non-OECD economies, suggesting the tradeoff between cyclical (short-run) components of unemployment and output is more pronounced in OECD economies. Second, while we find that the long-run relationship between unemployment and output is positive for the non-OECD subgroup, the corresponding short-run linkage turns out to be negative and significant.

Cross-state findings

In addition to cross-country sample, we also examine the results by using within-country, cross-state data to see if Okun's law continues to hold as well. Specifically, we consider the US as an illustration and include all 50 states in our full sample (Full). Moreover, we also study regional results by classifying each state into one of the following eight areas, i.e. New England, Mideast, Great Lakes, Plains, Southeast, Southwest, Rocky Mountain and Far West. In order the justify the use of PMG approach as our preferred estimator, we perform the Hausman tests for the full sample as well as eight regional subsamples. Although not reported, the test statistics suggest that we cannot reject the long-run parameter homogeneity null hypothesis for the full sample and for six out of eight regional subgroups (except for the Far West and Mideast).[5] As such, the PMG results are mostly preferred and, thus, displayed in Table 4.

As in the cross-country case, we first examine whether there exists a long-run, equilibrium

[5] Note that the Hausman test statistics appear to be negative for Far West and Mideast.

relationship between unemployment rate and output for the cross-state data. In the full sample, reported in column (1) of Table 4, the error correction coefficient ϕ has an (average) estimate as −0.3588 with SE 0.0139, which is significantly negative at 1% level, and thus lends strong support to a long-run cointegrated unemployment-output linkage. Similarly, the (mean) error correction estimates for the other eight regional subsamples, reported in columns (2)–(9) of Table 4, are ranging from −0.2268 (with SE 0.0104, Great Lakes) to −0.6918 (with SE 0.0653, Southwest). All of them are not only negative but also statistically significant at 1% level, and, thus, indicate the presences of long-term, cointegrating unemployment-output linkages for the regional data as well.

Given the existence of long-run relationships, we find that the long-run parameter between unemployment rate and (the logarithm of) real output is estimated to be −0.0299 with SE being 0.0016 for the complete sample. The long-term Okun's coefficient is negative, highly significant and economically large, and, even in the long run, Okun's law holds both across countries and across states. In particular, the estimate suggests that a one percentage increase in real output will reduce unemployment rate by 2.99%. Notice that this parameter estimate is also quantitatively very close to that (−0.0290) obtained by using the full cross-country data (column (1) of Table 3). Furthermore, the long-run coefficients between unemployment and output, ranging from −0.0927 (Great Lakes) to −0.0079 (Southwest) for alternative regional subsamples, are all negative and statistically significant at 1% level. It indicates that, even for regional data, there exists a long-run (Okun's) tradeoff (with different degrees) between unemployment and output.

In the short run, the (mean) autoregressive coefficient on the lagged unemployment variable has an estimate of 0.3895 (with SE 0.0231) and is significantly positive for the full sample. The value is larger than its cross-country counterpart (0.1702, column (1) of Table 3), and indicates that there is modest persistence of unemployment dynamics across states. Results from Columns (2)–(9) of Table 4 show that the autoregressive coefficients range from 0.2987 (Plains) to 0.5320 (Mideast), and, thus, confirm the view that unemployment rates are positively and significantly autocorrelated for distinct subsamples from alternative regions. By further restricting our attention on the short-run (average) Okun's coefficient, column (1) of Table 4 reports the estimate to be −0.1544 using the complete sample. As usual, the coefficient continues to be significantly negative, thus, confirming the validity of Okun's law even using state-level data. Moreover, while we find the long-run tradeoff between unemployment and output is quite similar (in magnitude) using both cross-country and cross-state (full) data, the corresponding short-run tradeoff is more pronounced when the cross-country data are considered (with an Okun's estimate of −0.2015). Finally, the regional Okun's (short-run) coefficients for all eight areas are still negative and statistically significant at 1% level, with values ranging from −0.3949 (Far West) to −0.1037 (Plains). Consequently, the validity of (short-run) Okun's linkage continues to hold not only for whole state-level data but also for regional data.

V. Conclusions

This study utilizes two extensive panel data sets, one with 53 countries for the 1980 to 2005 period while the other with 50 states over the 1976 to 2006 period, to re-examine the unemployment-output nexus, i.e. Okun' law, at different time horizons. By using the novel PMG approach, which does not require to pre-filter data and can allow for cointegration between (possibly nonstationary) unemployment and output, the following interesting results emerge.

First, except for the non-OECD countries, for all country- and state-level data and alternative subsamples, unemployment and output are cointegrated, suggesting that estimation of Okun's coefficients without considering this fact (e.g. using first-differenced data) can result in incorrect conclusions. Second, in line with the conventional Okun's literature, which mainly focus on the short-run link or cyclical components between unemployment and output, we find that, in the long run, there is also a tradeoff between these two important variables. Empirical inference results show that the long-run coefficients between unemployment and output are homogeneous (identical) across countries and states, negative, statistically significant and economically large. Third, there are overwhelming evidences in support of positive but modest unemployment rate dynamics across countries and states, Finally, on average, the short-run Okun's coefficients are found to be not only negative but also highly significant at 1% level and, thus, re-confirm the validity of Okun's law in large panels of countries and states.

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References

Adanu, K. (2005) A cross-province comparison of Okun's coefficient for Canada, *Applied Economics*, **37**, 561–70.

Apergis, N. and Rezitis, A. (2003) An examination of Okun's law: evidence from regional areas in Greece, *Applied Economics*, **35**, 1147–51.

Barro, R. (1991) Economic growth in a cross-section of countries, *Quarterly Journal of Economics*, **106**, 407–44.

Baxter, M. and King, R. G. (1999) Measuring business cycles: approximate band-pass filters for economic time series, *The Review of Economics and Statistics*, **81**, 575–93.

Blackburne, E. F. and Frank, M. W. (2007) Estimation of nonstationary heterogeneous panels, *Stata Journal*, **7**, 197–208.

Crespo-Cuaresma, J. (2003) Revisiting Okun's law: a piecewise-linear approach, *Oxford Bulletin of Economics and Statistics*, **65**, 439–51.

Freeman, D. G. (2001) Panel tests of Okun's law for ten industrial countries, *Economic Inquiry*, **39**, 511–23.

Glaeser, E. L., Scheinkman, J. A. and Shleifer, A. (1995) Economic growth in a cross-section of cities, *Journal of Monetary Economics*, **36**, 117–43.

Hamilton, J. D. (2001) A parametric approach to flexible nonlinear inference, *Econometrica*, **69**, 537–73.

Hansen, B. E. (2000) Sample splitting and threshold estimation, *Econometrica*, **68**, 575–603.

Harris, R. and Silverstone, B. (2001) Testing for asymmetry in Okun's law: a cross-country comparison, *Economics Bulletin*, **5**, 1–13.

Harvey, A. C. (1989) *Forecasting, Structural Time Series Models and the Kalman Filter*, Cambridge University Press, Cambridge.

Hodrick, R. J. and Prescott, E. C. (1997) Postwar US business cycles: an empirical investigation, *Journal of Money, Credit and Banking*, **29**, 1–16.

Holmes, M. J. and Silverstone, B. (2006) Okun's law, asymmetries and jobless recoveries in the United States: a Markov-switching approach, *Economics Letters*, **92**, 293–9.

Huang, H. C. and Chang, Y. K. (2005) Investigating Okun's law by the structural break with threshold approach: evidence from Canada, *Manchester School*, **73**, 599–611.

Huang, H. C. and Lin, S. C. (2006) A flexible nonlinear inference to Okun's relationship, *Applied Economics Letters*, **13**, 325–31.

Huang, H. C. and Lin, S. C. (2008) Smooth-time-varying Okun's coefficients, *Economic Modelling*, **25**, 363–75.

Lee, J. (2000) The robustness of Okun's law: evidence from OECD countries, *Journal of Macroeconomics*, **22**, 331–56.

Moosa, I. A. (1997) A cross-country comparison of Okun's coefficient, *Journal of Comparative Economics*, **24**, 335–56.

Moosa, I. A. (1999) Cyclical output, cyclical unemployment, and Okun's coefficient: a structural time series approach, *International Review of Economics and Finance*, **8**, 293–304.

Okun, A. M. (1962) Potential GNP: its measurement and significance, in *Proceedings of the Business and Economic Statistics Section*, American Statistical Association.

Perman, R. and Tavera, C. (2005) A cross-country analysis of the Okun's law coefficient convergence in Europe, *Applied Economics*, **37**, 2501–13.

Perman, R. and Tavera, C. (2007) Testing for convergence of the Okun's law coefficient in Europe, *Empirica*, **34**, 45–61.

Pesaran, M. H. and Shin, Y. (1999) An autoregressive distributed lag modelling approach to cointegration analysis, in *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, Chap. 11 (Ed.) S. Strom, Cambridge University Press, Cambridge, pp. 371–413.

Pesaran, M. H., Shin, Y. and Smith, R. P. (1999) Pooled mean group estimation of dynamic heterogeneous panels, *Journal of the American Statistical Association*, **94**, 621–34.

Pesaran, M. H., Shin, Y. and Smith, R. J. (2001) Bounds testing approaches to the analysis of level relationships, *Journal of Applied Econometrics*, **16**, 289–326.

Pesaran, M. H. and Smith, R. P. (1995) Estimating long-run relationships from dynamic heterogeneous panels, *Journal of Econometrics*, **68**, 79–113.

Silvapulle, P., Moosa, I. A. and Silvapulle, M. J. (2004) Asymmetry in Okun's law, *Journal of Economics*, **37**, 353–74.

Sögner, L. (2001) Okun's law: does the Austrian unemployment-GDP relationship exhibit structural breaks?, *Empirical Economics*, **26**, 553–64.

Sögner, L. and Stiassny, A. (2002) An analysis on the structural stability of Okun's law – a cross-country study, *Applied Economics*, **14**, 1775–87.

Villaverde, J. and Maza, A. (2009) The robustness of Okun's law in Spain, 1980–2004: regional evidence, *Journal of Policy Modeling*, **31**, 289–97.

Virén, M. (2001) The Okun curve is non-linear, *Economics Letters*, **70**, 253–7.

Weber, C. (1995) Cyclical output, cyclical unemployment, and Okun's coefficient: a new approach, *Journal of Applied Econometrics*, **10**, 433–45.

Yazgan, M. E. and Yilmazkuday, H. (2009) Okun's convergence within the US, *Letters in Spatial and Resource Sciences*, **2**, 109–22.