Output Shocks and Unemployment: New Evidence on Regional Disparities

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Abstract We estimate five VAR models and use generalized impulse response functions to examine the relationship between output and unemployment at the regional level. Further, within regions we consider the degree to which the cyclical nature of unemployment might vary across race and gender groups. We find some variation in the relationship between output and unemployment across regions, and interestingly, we find that this relationship differs among demographic groups within, and between, regions of the United States.

Keywords: Output, unemployment, generalized impulses

JEL Classifications: C22, E24, R23

Introduction

One goal of U.S. economic policy makers is to achieve full employment. Consequently, understanding the cyclical component of unemployment is of great importance to economists and policy makers alike. This has given rise to a vital strand of macroeconomic research regarding the link between output and unemployment, and the study of this link has received considerable attention in the literature. Although the topic has been studied and discussed for quite some time, some aspects remain relatively unexplored, and innovations in econometric methods have yet to be fully utilized in this context. Here we hope to rectify these shortcomings in the literature.

While past authors have shown that shocks to output may not impact unemployment rates equally across race, gender, and region, some relatively recent econometric developments remain unexploited, and some questions remain unanswered. We know of no study which uses vector autoregressive techniques and associated generalized impulse response functions to examine regional disparities in the impact of output shocks on the unemployment rate. This is particularly important given the recommendations of Pesaran and Shin (1998) on the usefulness of such techniques. Further, we know of no other study which examines the degree to which output shocks may affect certain race/gender groups differently across regions. The purpose of this study is therefore twofold. First, through the use of generalized impulse response functions we seek to determine the degree to which the impact of output shocks may differ across regions. Second, we aim to discern any possible regional differences in the responses of certain race and gender groups to such shocks.
Background Literature

The relationship between output and unemployment has become known as Okun’s Law, and dates back to 1962 when Arthur Okun first documented that there was a systematic relationship between deviations of output from its full employment level and the unemployment rate. Roughly put, Okun’s law says that there is an “approximate 3-to-1 link between output and unemployment.” Over the years Okun’s law has been revised so that nowadays economists believe that a more appropriate description is given by a 2-to-1 ratio (Romer (1996, p. 150)).

Furthermore, the effect of output deviations from the full employment trend on the unemployment rate are now also believed to be different for different races, genders, age groups, and geographical areas. Two representative studies of the link between output and unemployment by demographic characteristics are Lynch and Hyclak (1984) and Ewing, Levernier and Malik (2002). Lynch and Hyclak (1984) calculate how output deviations from full employment affect the unemployment rate by age, gender and race. They find that unemployment rates of teens (as opposed to adults), men (as opposed to women) and nonwhites (as opposed to whites) are more sensitive to GNP deviations from its full employment level. They also find that the unemployment rate of nonwhite teenagers is fully felt in the current period, whereas the unemployment rates of the other groups react to output shocks with a lag.

Ewing, Levernier and Malik (2002) study how unanticipated output shocks affect the unemployment rate by gender and race using VARs and generalized impulse response functions. They find that overall the impact of an output shock is larger (in absolute value) for black females than for white females, and for black males than for white males.

Representative studies of the relationship between output and unemployment by region include Blackley (1991), Freeman (2000), and Izraeli and Murphy (2003). Blackley (1991) calculates Okun’s law for the largest 26 states in the U.S, and he finds that there is a significant difference in the reaction of unemployment to output changes by state. For most states Okun’s coefficient is between 2.0 and 4.0, the smallest coefficient being Alabama with a 2.137, and the largest being Louisiana’s with a 6.803. In general he finds that the unemployment rate is more sensitive to output fluctuations in states with low labor force growth rates, large male participants in the labor force, high dependence on manufacturing, and high income tax rates.

Freeman (2000) estimates Okun’s law using national and regional U.S. data. He finds that Okun’s coefficient is stable over time and across regions at a value of approximately 2. Finally, Izraeli and Murphy (2003) study how the degree of industrial diversification influences unemployment rates and per capita income in 17 states. Their work shows that states with a more diversified industrial base have lower unemployment rates. Evidence on the relationship between industrial diversification and income however is not conclusive.

In our opinion, Blackley’s (1991) and Izraeli and Murphy’s (2003) results suggesting that the relationship between output and unemployment varies by state warrants further analysis. In particular we believe that more sophisticated econometric techniques can be used to disentangle the effect of output shocks on unemployment rates by region. Further, the work of Ewing, Levernier and Malik (2002) can be expanded to determine the degree to which race/gender disparities might vary across regions. Therefore, through the use of generalized impulse response functions, we extend the literature by examining the impact of unanticipated output changes on certain regional unemployment rates. We first estimate the impact of an output shock on the unemployment rate in each of four census regions. We then estimate the effect of such a shock on the unemployment rates of race/gender groups within each region. Our work is closely related
to Ewing, Levernier and Malik (2002). In particular, we use the same methodology but we expand upon their work by estimating various regional impulse response functions.

**Theoretical Model and Methodology**

The basic relationship between output and unemployment can be expressed according to Okun’s law as follows,

\[ U_t - U_t^* = b(y_t - y_t^*) , \]  

where \( b < 0 \). According to Okun’s law, the unemployment rate \( U_t \) deviates from its natural rate \( U_t^* \), whenever real output \( y_t \) deviates from potential output \( y_t^* \). In equation (1), both output and potential output are expressed in logarithms. Primarily following Tatom (1978) and Lynch and Hyclak (1984), we expand Okun’s law to allow for output lag effects of up to \( n \) periods. We therefore expand equation (1) as follows,

\[ (U_t - U_t^*) = \sum_{i=0}^{n} b_i (y_{t-i} - y_{t-i}^*) . \]  

(2)

From equation (2) it is clear that any shock in the output gap will have a contemporaneous, and perhaps lasting, impact on the unemployment rate gap. Therefore, the relationship presented in equation (2) is the rationale behind our VAR estimations concerning unemployment rates broken down by region, gender and race, where we use generalized impulse response functions to determine the impact of unanticipated output shocks on the different unemployment rates.

In our econometric analysis we employ a series of VARs which include a measure of the deviation of aggregate output from its potential and the deviation of certain unemployment rates from their natural levels. VARs are well-suited to the task of estimating complex macroeconomic relationships as they treat each variable in the model as endogenous, therefore yielding a system of equations where each variable is expressed in terms of its own lagged values and the lagged values of all other variables in the model. We first estimate a five variable VAR which is comprised of the aggregate output gap and the unemployment rate gap for the northeast, south, midwest, and west U.S. census regions. We then estimate a separate VAR model for each census region which includes the aggregate output gap and the unemployment rate gap for each of four demographic groups within the region. Each model was found to have an optimal lag length of three months, as was determined by the Akaike Information Criteria and the Schwartz criteria. Therefore, all of the VARs that we estimate take the form,

\[ X_t = \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \alpha_3 X_{t-3} + \epsilon_t , \]  

(3)

where \( X_t \) is a 5x1 vector of endogenous variables, \( \alpha_1 \), \( \alpha_2 \) and \( \alpha_3 \) are the parameter matrices to be estimated, and \( \epsilon_t \) is the vector of innovations. In our first VAR, the vector \( X_t \) includes the following variables,
where $UGAP_j^\ell = U_j^\ell - U_j^{\ell,*}$ denotes the unemployment gap (unemployment rate minus natural unemployment rate) in region $j$ at time $t$, and where the four regions are $j=$ Northeast (NE), Midwest (MW), South (S), and West (W).

We also estimate four other VARs, one for each of the four regions. The vector of endogenous variables for region $j$ includes the following variables,

$$[y_t - y_t^*, UGAP_{j,WM}^\ell, UGAP_{j,WF}^\ell, UGAP_{j,NWM}^\ell, UGAP_{j,NWF}^\ell],$$

where $UGAP_{j,d}^\ell = U_j^{d,j} - U_j^{d,j,*}$ denotes the unemployment rate gap for demographic group $d$ in region $j$ at time $t$. The four demographic groups are $d=$ white males (WM), white females (WF), nonwhite males (NWM) and nonwhite females (NWF).

For each data series in the model, we construct a measure of the gap between the series’ actual level and the potential/full employment level for that variable. We use the Hodrick-Prescott filter to calculate the potential level of output for the aggregate output series, and the natural rate of unemployment for each unemployment rate series. For example, the potential output level is found by solving,

$$\min_{\{y_t^*, y_{t-1}^*, \ldots, y_{t-T}^*\}} \left\{ \sum_{t=1}^{T} (y_t - y_t^*)^2 + \theta \sum_{t=1}^{T} \left[ (y_t^* - y_{t-1}^*) - (y_{t-1}^* - y_{t-2}^*) \right]^2 \right\},$$

where $\theta > 0$ (Hodrick and Prescott, 1997, p. 3).

The measure of aggregate output used to construct each series is the Industrial Production Index (IPI) as is available from the FRED II website maintained by the St. Louis Fed. The overall regional unemployment rates are those published by the Bureau of Labor Statistics. The regional unemployment rates decomposed by race and gender are unpublished data provided by the Bureau of Labor Statistics. The sample period for which data is available ranges from January 1978 through July of 2001, with the exception of the aggregate regional model which begins in January of 1980. Each data series is monthly and seasonally adjusted. Since it is well-known that data series must be stationary to be properly employed in time series analysis, we tested each data series using the Augmented Dickey Fuller test and found that while each unemployment and output series was not stationary, each gap series was stationary, and therefore differencing was not required. Each data series is monthly, and seasonally adjusted.

**Results**

The results of our VAR estimation are presented in Graphs 1-5. Graph 1 relates to the impact of a shock to the output gap on the unemployment rate gap of each region. Graphs 2-5 concern the impact of the same output shock on the various groups within each region. Data limitations restrict our analysis to white/nonwhite, male/female comparisons. In each case we provide the response of each unemployment rate gap to a one standard deviation shock in the
aggregate output gap. We do this through the use of generalized impulse response functions as discussed by Presaran and Shin (1998).

Though the Cholesky decomposition is commonly used to generate impulse response functions, the results associated with the method can vary substantially based upon the ordering of the variables in the model. The generalized impulse response function, however, is an especially useful tool as the results obtained using this method are independent of variable ordering. To calculate generalized impulse response functions, we first write our VAR as an infinite moving average as follows,

\[ X_t = \sum_{i=0}^{\infty} C_i \varepsilon_{t-i}, \]

where \( C_i \) is a 5x5 matrix of parameters such that \( C_0 = I_5 \), \( C_i = \alpha_i C_{i-1} + \alpha_2 C_{i-2} + \alpha_3 C_{i-3} \) for \( i > 0 \), and \( C_i = 0 \) for \( i < 0 \). We then calculate the scaled generalized impulse response of a one standard error shock to the \( j \)th equation at time \( t \) on the entire system at time \( t+n \) (\( X_{t+n} \)) as,

\[ \frac{C_j \sum e_i}{\sqrt{\sigma_{jj}}}, \quad n=0,1,2,3,... \]

where \( e_j \) is a 5x1 vector with a value of one in the \( j \)th element and zero everywhere else, and \( \sigma_{jj} \) is a one standard error shock (Pesaran and Shin (1998)). This method yields results independent of variable ordering, and is the basis for our impulse response functions presented below.

We present the generalized impulse response functions for our first regional model in Graph 1. Here we examine the differential impact of a shock to output on the unemployment rate in each of four U.S. census regions. The results here are quite interesting. From Graph 1 it is clear that, to a certain extent, the reaction of unemployment rate gaps to a deviation in output from its potential varies across regions. The largest reaction occurs in the Midwest, with a similar reaction occurring in the South. The Northeast experiences the third largest response, with the smallest response in the West. Though the differences here are not particularly pronounced, these results seem to be reasonably consistent with past work. For instance, Blackley (1991) suggests that the relationship between output and unemployment varies across states in the U.S., and Carlino and Defina (1998) find that the impact of monetary policy is not evenly felt across regions. Neither of the studies cited above, however, make use vector autoregressive techniques with generalized impulses. Our results, therefore, provide further evidence regarding regional disparities in the reaction of unemployment rates to aggregate output shocks, and are based upon methods independent of the identification method employed.

Graph 2 contains our results concerning the impact of output shocks on the unemployment rate gap of certain race/gender groups in the Northeast census region of the United States. Here we find that the unemployment rate of various demographic groups does not respond equally to an output shock. Specifically, the unemployment rate of nonwhite males is considerably more responsive to an unanticipated shock to output than are the unemployment rates of other groups. These results are reasonably consistent with those found by Ewing, Levernier and Malik (2002) who find that males are generally more responsive to shocks than females, and that the black unemployment rate is more responsive to output shocks than is white
unemployment. However, while the gender differences are consistent with past work, we find that nonwhite females actually experience a smaller effect than do white males. The response of nonwhite female unemployment is, in fact, negligible and smaller than is the case for white females.

In Graph 3 we present similar results for the Midwest region. Here we find results that are fairly consistent with the aggregate national results found by previous authors. Males have a larger response than females, and nonwhites a larger response than whites. Interestingly the response of nonwhite females is considerably larger than white males, which is a substantially different conclusion from that drawn in the northeast. While our current methodology is not designed to offer explanations for this inconsistency, our results do suggest that the relative response of the unemployment rate of groups may differ across regions of the country.

We present the results for the same type of analysis for the South region in Graph 4. Here we find results that are similar to the Northeast. While nonwhite males have a larger impact than white males, and males have a larger response than females of the same race, nonwhite females experience a response that is quite similar to white females, and less than the response of white males.

Finally, the results for the West are presented in Graph 5. In the West nonwhite males and nonwhite females experience the largest response to an output shock, though the timing of their responses vary considerably. White males experience the next largest response, though white females and white males appear to have very similar responses. Though the interpretation of the results for the West region is a bit less clear, it appears that the differences in the West are driven more by race than by gender.

To help summarize our findings, in Table 1 we present the relative maximum response of each group in every region to a shock to the aggregate output gap. This table accentuates the fact that the relative impact of an output shock is not equal across all regions of the country. Note especially that the response of nonwhite females relative to nonwhite males ranges from 7.55% in the Northeast, to 98.56% in the West. Also, in the Northeast, nonwhite females have the lowest relative response of all demographic groups whereas in the West and Midwest regions, nonwhite females have the highest relative response of all groups. In all other regions, white males have the highest relative response, followed by white females. Further, white females have the lowest relative response in the West, Midwest, and South. These results from Table 1 emphasize the fact that aggregate output shocks impact aggregate regional unemployment rates unequally, and also impact demographic groups unequally within regions. In addition, the nature of these race/gender disparities differ across regions.

Conclusion

We examine the relationship between output shocks and various unemployment rates disaggregated by region, race and gender. While previous authors have studied the impact of output shocks by race and gender, and limited work has been done on regional differences, we know of no other study which has examined this impact by race and gender across regions, nor do we know of another study which has used generalized impulse response functions to look into such regional differences. Interestingly, our results suggest that in the aggregate the response of the unemployment rate to an output shock is somewhat different across regions, and that when broken down by race and gender, demographic groups do not experience a similar response. In
fact, not only is the response of each group different, but the relative response varies across regions as well. Further, the regional results are not entirely consistent with race/gender studies which have focused on race/gender responses at the national level.

Footnotes

1. Okun (1970), p. 137. This is a quote from Okun’s (1962) original article as reprinted in Okun (1970).

2. We need to estimate the natural unemployment rate and potential output. Usually in the literature this is done by calculating the trend of the series. Two common ways of doing so are the Hodrick-Prescott filter (Hodrick and Prescott, 1997) and the Band-pass filter developed by Baxter and King (1999). For a discussion of these two alternatives see Freeman (2000) and Apergis and Rezitis (2003). In this paper we follow Ball and Mankiw (2002) and use the Hodrick-Prescott filter to calculate the trends of the series.

3. Though standard error bands are not included for the sake of presentation, only the negative portion of the IRFs were found to be significant by that measure.

References


Graph 1. Response to Output Shock: Regions

Graph 2. Response to Output Shock: Northeast
Graph 3. Response to Output Shock: Midwest

Graph 4. Response to Output Shock: South
Graph 5. Response to Output Shock: West

Table 1. Group Maximum Response Relative to Nonwhite Males

<table>
<thead>
<tr>
<th>Region</th>
<th>White Males</th>
<th>White Females</th>
<th>Nonwhite Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>44.04%</td>
<td>23.75%</td>
<td>7.55%</td>
</tr>
<tr>
<td>Midwest</td>
<td>45.69%</td>
<td>20.86%</td>
<td>73.08%</td>
</tr>
<tr>
<td>South</td>
<td>53.57%</td>
<td>31.88%</td>
<td>34.47%</td>
</tr>
<tr>
<td>West</td>
<td>53.76%</td>
<td>52.44%</td>
<td>98.56%</td>
</tr>
</tbody>
</table>