



Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/econmod

The Great Recession and Okun's law

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ARTICLE INFO

JEL classification:

C11
C15
C52
C58

Keywords:

Time variation
Output gap
Unemployment gap

ABSTRACT

The relationship between output and unemployment has been a widely discussed topic since the Great Recession. This paper jointly estimates a time-varying parameter Okun's law with two latent states: potential output and the natural rate of unemployment. It is found that there is substantial time variation in the Okun's coefficient in the US. Since the Great Recession, a given unemployment gap has been associated with a smaller output gap. The probability that the Okun's coefficient is equal to the widely accepted value of -2 fell significantly during the Great Recession, but has since risen despite the Okun's coefficient remaining at around -0.5 . This illustrates the significant degree of uncertainty in the estimation of potential output and the natural rate of unemployment.

1. Introduction

The relationship between output and unemployment has been a widely discussed topic since the Great Recession. The literature has examined the pattern of jobless recoveries, changes in the persistence of the unemployment rate and the difference between labor market outcomes in financial recessions versus other recessions (see, e.g., Stock and Watson, 2012; Basu and Foley, 2013; Boeri et al., 2013; Calvo et al., 2013; Valadkhani and Smyth, 2015; Hall, 2017; Marques et al., 2017).

This paper aims to add further to this empirical literature. More specifically, it examines whether Okun's law—the empirical relationship between unemployment and output that was first observed by Okun (1962)—still holds. To do this, it estimates a time-varying gap version of Okun's law, which allows for stochastic volatility in the output gap equation. In addition, formal inference is conducted to determine whether the Okun's coefficient is statistically different from the traditional estimate of -2 . This is important given parameter uncertainty, but is not usually done in the literature.

The gap version of Okun's law relates the output gap to the unemployment gap, where the output gap is the difference between actual and potential log output and the unemployment gap is the difference between the actual and natural rate of unemployment. In contrast, the difference version of Okun's law postulates a linear relationship between the first difference of the log of output and the first difference of the unemployment rate. While the difference version is easier to estimate, the gap version has the advantage of taking into account the state of the economy compared with its trend or natural

state. In fact, the gap version is a more general version of the relationship in difference terms (see, e.g., Guisinger et al., 2015). The gap version collapses to the difference version if it is assumed that potential growth and the natural rate of unemployment are constant. Given that there are a number of reasons to expect that this would not be the case, the gap version would appear to be a better estimation choice than the difference version.

There are also many reasons why the relationship between unemployment and output would not be constant. Most notably, it would be reasonable to expect structural changes over time in productivity and the labor market. A number of researchers have examined structural instability in the Okun's coefficient using a variety of estimation techniques. Some focus on structural breaks (see, e.g., Weber, 1995; Lee, 2000; Galí et al., 2012; Ball et al., 2013), some focus on general time variation (see, e.g., Sögner and Stiasny, 2002; Huang and Lin, 2008; Beaton, 2010), and others focus on whether the relationship is asymmetric over the business cycle (see, e.g., Cuaresma, 2003; Silvapulle et al., 2004; Holmes and Silverstone, 2006; Wang and Huang, 2017). However, most of the literature focuses on the difference version rather than the gap version of Okun's law.

The smaller number of papers that focus on time variation in the gap version of Okun's law tend to consider only a restricted form of time variation. They also generally use two-stage estimation procedures, where the estimates of potential output and the natural rate of unemployment are obtained from filters or modeled using a deterministic trend. The exceptions are Huang and Lin (2008) who propose a smooth time-varying parameter approach that allows the coefficients to shift in a non-parametric but smooth way, Valadkhani and Smyth

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¹ I would like to thank Joshua Chan for helpful comments.

<http://dx.doi.org/10.1016/j.econmod.2017.10.002>

Received 1 June 2017; Received in revised form 27 August 2017; Accepted 2 October 2017
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(2015) who use a Markov switching model that allows for asymmetries within and across regimes, and Berger et al. (2016) who estimate a multivariate unobserved components model with time-varying parameters and stochastic volatility.

A time-varying parameter model is a less restricted form of time variation than considering specific structural breaks or using rolling regressions. In addition, the estimation allows for the joint estimation of potential output, the natural rate of unemployment and the model parameters, in contrast to a two-stage estimation procedure where the latent variables are either obtained from filters or modeled using a deterministic trend. This improves efficiency and avoids the problem of attenuation bias. It is particularly preferable to the use of filters, which suffer from attenuation bias and can generate spurious cycles (see, e.g., King and Rebelo, 1993; Cogley and Nason, 1995; Canova, 1998). Further, given the empirical relevance of time-varying volatility in macroeconomic variables, the estimation allows for stochastic volatility in the output gap equation. The modeling framework is closest to Chan et al. (2016) and Berger et al. (2016). However, the former focuses on forecasting inflation, while the latter focuses on testing time variation against time-invariant specifications rather than testing the value of the Okun's coefficient.

The estimation of a time-varying gap version of Okun's law shows substantial time variation in the Okun's coefficient in the US, with rises in the coefficient often experienced during recessions. Before 1980 the coefficient fluctuates between -2.5 and -2 , which is close to the widely accepted value of -2 . After this it increases substantially and fluctuates between -1.5 and -1 before the onset of the Great Recession. During the Great Recession the coefficient increases substantially and makes further gains following the worst of the recession. The coefficient is estimated to most recently be around -0.5 , which is only one-quarter of the widely accepted value of the coefficient. This means that a given unemployment gap has been associated with a smaller output gap over the sample period of 1948Q1 to 2016Q4. While some of the shift in the Okun's coefficient may be reversed as the effects of the Great Recession continue to recede, a significant proportion of the increase in the coefficient occurred before the onset of the Great Recession. This may indicate that a structural shift in the relationship was already underway, possibly as a result of structural shifts in the labor market or productivity.

However, parameter uncertainty around the Okun's coefficient means that the estimated coefficient might not be statistically different from the traditional estimate of -2 . This is formally tested by computing the dynamic probabilities that the Okun's coefficient is equal to -2 using the methodology in Koop et al. (2010). It is found that before the Great Recession the Okun's coefficient is equal to -2 with high probability despite the parameter estimate having increased substantially. The probability that the coefficient is equal to -2 then falls substantially as a result of the Great Recession, but has since risen despite the coefficient remaining at around -0.5 .

The remainder of this paper is organized as follows. Section 2 outlines the bivariate unobserved components model used for the analysis. Section 3 describes the data and presents the empirical results. Section 4 concludes.

2. Bivariate unobserved components model

This section introduces the bivariate unobserved components model with time-varying parameters and stochastic volatility, similar to that in Chan et al. (2016). More specifically, consider the following bivariate model for (log) output, y_t , and the unemployment rate, u_t :

$$(y_t - y_t^*) = \lambda_t(u_t - u_t^*) + \varepsilon_t^y, \quad (1)$$

$$(u_t - u_t^*) = \varepsilon_t^u, \quad (2)$$

where y_t^* and u_t^* are potential output and the natural rate of unemployment respectively.

Eq. (1) is based on one of the empirical relationships specified by Okun (1962). More specifically, this is the gap version of Okun's law where the deviation of output from its potential, $y_t - y_t^*$, depends on the deviation of the unemployment rate from its natural rate, $u_t - u_t^*$. For example, when the unemployment rate is equal to its natural rate, output equals its trend or potential on average. When there is an increase in the unemployment gap, real output will be below its potential. In contrast to the original specification in Okun (1962), the relationship between the output gap and the unemployment gap is time-varying. In addition, it is assumed that the variance of the transitory component is time-varying via a stochastic volatility process, i.e., $\varepsilon_t^y \sim \mathcal{N}(0, e^{h_t})$.

The deviation of the unemployment rate from its natural rate is assumed to follow an AR(2) process:

$$\varepsilon_t^u = \rho_1 \varepsilon_{t-1}^u + \rho_2 \varepsilon_{t-2}^u + \eta_t, \quad (3)$$

where $\eta_t \sim \mathcal{N}(0, \sigma_\eta^2)$ and $\varepsilon_0^u = \varepsilon_{-1}^u = 0$. The unemployment gap is modeled as a stationary AR(2) process to ensure that the typically high persistence in the unemployment gap is taken into account. The time-varying parameter and stochastic volatility process evolve according to the following random walk processes:

$$\lambda_t = \lambda_{t-1} + \varepsilon_t^\lambda, \quad (4)$$

$$h_t = h_{t-1} + \varepsilon_t^h, \quad (5)$$

where ε_t^λ and ε_t^h are independent $\mathcal{N}(0, \sigma_\lambda^2)$ and $\mathcal{N}(0, \sigma_h^2)$ respectively. These state equations are initialized with $\lambda_1 \sim \mathcal{N}(\lambda_0, V_\lambda)$ and $h_1 \sim \mathcal{N}(h_0, V_h)$.²

Potential output and the natural rate of unemployment also follow random walk processes:

$$y_t^* = \gamma + y_{t-1}^* + \varepsilon_t^{y*}, \quad (6)$$

$$u_t^* = u_{t-1}^* + \varepsilon_t^{u*}, \quad (7)$$

where ε_t^{y*} and ε_t^{u*} are independent $\mathcal{N}(0, \sigma_{y*}^2)$ and $\mathcal{N}(0, \sigma_{u*}^2)$ respectively, and the processes are initialized with $y_1^* \sim \mathcal{N}(y_0^*, V_{y*})$ and $u_1^* \sim \mathcal{N}(u_0^*, V_{u*})$.^{3,4}

2.1. Priors

The following independent prior distributions are assumed for the model parameters:

$$\rho \sim \mathcal{N}(\rho_0, \mathbf{V}_\rho), \quad \gamma \sim \mathcal{N}(\gamma_0, V_\gamma), \quad \sigma_\lambda^2 \sim \mathcal{IG}(\nu_\lambda, S_\lambda), \quad \sigma_h^2 \sim \mathcal{IG}(\nu_h, S_h),$$

$$\sigma_{y*}^2 \sim \mathcal{IG}(\nu_{y*}, S_{y*}), \quad \sigma_{u*}^2 \sim \mathcal{IG}(\nu_{u*}, S_{u*}), \quad \sigma_u^2 \sim \mathcal{IG}(\nu_u, S_u),$$

where $\rho = (\rho_1, \rho_2)'$ and $\mathcal{IG}(\cdot, \cdot)$ denotes the inverse-gamma distribution. More specifically, the following proper, but relatively noninformative hyperparameters, are chosen: $\rho_0 = (0.8 \ 0.1)'$, $\mathbf{V}_\rho = \text{diag}(1, 1)$, $\gamma_0 = 0$, $V_\gamma = 5$, $\nu_\lambda = \nu_h = \nu_{y*} = \nu_{u*} = \nu_u = 5$, $S_\lambda = S_h = 0.04$, $S_{y*} = S_{u*} = 0.4$ and $S_u = 1$. These priors give: $E(\sigma_\lambda^2) = E(\sigma_h^2) = 0.01$, $E(\sigma_{y*}^2) = E(\sigma_{u*}^2) = 0.1$ and $E(\sigma_u^2) = 0.25$. The prior mean for ρ is set based on the belief that the unemployment gap is persistent and stationary, while the other priors have been set similar to those in the literature (see, e.g., Chan et al., 2016).

² The inclusion of stochastic volatility in the measurement equation for output is important given the pioneering work of Cogley and Sargent (2005); Primiceri (2005) and Sims and Zha (2006). It is less common, however, for the literature to account for stochastic volatility in the unemployment rate (see, e.g. Chan et al., 2016).

³ This model is a standard bivariate unobserved components model and identification is achieved without the need for restricting the variances: u_t^* is identified by Eqs. (2) and (3) so Eq. (1) becomes a time-varying parameter model with a time-varying intercept (y_t^*) and a time-varying parameter (λ_t).

⁴ This specification is similar to that in Berger et al. (2016), but they regress the unemployment gap on the output gap. Due to different specifications, there are notable differences in the timing and magnitude of the changes in the Okun's coefficient.

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