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Testing for time variation in an unobserved components model for the U.S. economy

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ABSTRACT

This paper analyzes the amount of time variation in the parameters of a reduced-form empirical macroeconomic model for the U.S. economy. We decompose output, inflation and unemployment in their stochastic trend and business cycle gap components, with the latter linked through the Phillips curve and Okun's law. A novel Bayesian model selection procedure is used to test which parameters vary over time and which components exhibit stochastic volatility. Using data from 1959Q2 to 2014Q3 we find substantial time variation in Okun's law, while the Phillips curve slope appears to be stable. Stochastic volatility is found to be important for cyclical shocks to the economy, while the volatility of permanent shocks remains stable.

1. Introduction

Over the last decades the U.S. economy has experienced a number of notable structural changes. Well documented are the productivity slowdown in the early 1970s and the reduction in the volatility of key macroeconomic variables in the mid 1980s, known as the Great Moderation. More recently, due to the experience of the 2001 recession and the Great Recession, the interest in the academic literature in analyzing structural changes has been renewed. In particular, during the Great Recession, with unemployment being very high, most Phillips curve estimates imply that prices should have fallen much more than what the actual data show. This case of missing deflation has cast doubt on the stability of the Phillips curve. Furthermore, in the aftermath of the last two recessions, job growth appeared substantially lower than what the level of output growth would have implied. These episodes, known as 'jobless recoveries', have led many observers to conclude that the trade-off between unemployment and output has changed. Finally, the severity of the Great Recession and the related increases in the volatility of key macroeconomic variables may herald the end of the Great Moderation.

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A growing literature investigates time variation in macroeconomic relationships. First, the necessity for empirical models to account for changes in the volatility of macroeconomic variables has been emphasized by Hamilton (2008) and Fernández-Villaverde and Rubio-Ramírez (2010), the former showing that not accounting for volatility changes can lead to biased estimates and misleading inference. Second, regarding the relationship between inflation and real economic activity, the literature has collected growing evidence for a change in the slope of the Phillips curve. Ball and Mazumder (2011) forecast inflation over the period 2008–2010 using backward-looking Phillips curve estimates for the period 1960–2007. The model predicts substantial deflation, which is not in line with the slightly positive actual inflation rate observed over this period. Hall (2011) also emphasizes the case of missing deflation during the Great Recession and notes that inflation remained remarkably stable at a small but positive rate despite the large and persistent slack in real activity. Roberts (2006) analyzes U.S. data prior to the Great Recession and finds that the reduced-form Phillips curve slope fell by nearly half between the periods 1960–1983 and 1984–2002. Similar results can be found in Atkeson and Ohanian (2001) and Mishkin (2007). Regarding the relationship between unemployment and real economic activity, a different strand of the literature investigates the stability of Okun's law. Daly et al. (2012) note that if Okun's law had held in 2009, the U.S. unemployment rate would only have risen by about half of the observed rise. Owyang and Sekhposyan (2012) conclude that the relationship between unemployment and output fluctuations changes significantly during the most recent recession periods. Lee (2000) reports international evidence for structural breaks in the Okun coefficient during the 1970s. Contradicting evidence is given by Ball et al. (2013), who find that Okun's law is a 'strong and stable' relationship.

Measuring these various types of structural change is challenging as it relates to variables that are not directly observed. The Phillips curve links inflation to expected inflation and to a measure for the deviation of real economic activity from its potential, such as the output gap or the unemployment gap. Each of these determinants is unobserved. The same argument holds for Okun's law, which models the interaction between the output gap and the unemployment gap.[1] To proxy these unobserved factors, many studies rely on purely statistical trend-cycle decompositions based on filtering techniques – such as the Hodrick–Prescott filter – or use external estimates provided by a statistical bureau – such as the Congressional Budget Office's (CBO) series for the U.S. economy. The first approach suffers from a lack of structural interpretation while the second entails the risk of falling into an endogeneity trap. The CBO for instance follows a growth model for calculating potential output thereby relying on constant values for the slope of the Phillips curve and Okun's law coefficient. As such, these slopes and their stability are artificially imposed on the data from the outset.

In this paper, we set up and estimate a multivariate unobserved components model for the U.S. economy to jointly estimate a time-varying NAIRU, trend inflation, potential output, and the respective gaps. Important model parameters are allowed to change over time. Specifically, we allow the forward-looking New Keynesian Phillips curve slope, Okun's law coefficient, the growth rate of potential output and the variances of the innovations to all unobserved components to vary over time.

The model in our paper is most closely related to the following recent papers. First, Stella and Stock (2012) estimate the time-varying trend inflation and the NAIRU using a bivariate unobserved components (UC) model with stochastic volatility (SV). While the Phillips curve slope is treated as constant in the forward-looking inflation equation, the implied backward-looking Philips curve has a time-varying slope parameter which is found to vary considerably. Second, Chan et al. (2016) build on this model and use a bounded random walk specification for the trend components. However, their analysis can be understood as a forecasting exercise as less emphasis is put on time variation in the parameters. They stick to a bivariate model of inflation and unemployment. Third, Kim et al. (2014) allow for two structural breaks in the slope of the U.S. New Keynesian Phillips curve. The sensitivity of inflation to the CBO output gap is found to be small but significant prior to 1971, while being insignificant from 1971 onwards.

Another strand of the literature analyses time variation in the parameters of vector autoregressive (VAR) models. Well known contributions, focussing on potential changes in the conduct of monetary policy, include Sims and Zha (2006) who estimate a VAR with Markov-switching parameters and Cogley and Sargent (2005), Cogley et al. (2010), and Primiceri (2005) who estimate VARs with time-varying parameters (TVP-VAR) that evolve as random walks. TVP-VARs are a very flexible tool since they allow for different types of structural change, i.e. time variation in the persistence, in the correlation structure and in the conditional variances. However, they suffer from an over-parameterization problem that can seriously impact estimation accuracy (see e.g. Chan et al., 2012). To deal with this problem, the TVP-VAR literature uses small dimensional models with a low number of lags (Cogley and Sargent, 2005, for instance estimate a trivariate VAR with two lags) and typically sets tight priors for the time-varying parameters. Hence, the amount of time variation in the posterior estimates may be largely driven by the priors (see e.g. Reusens and Croux, 2015). Our UC model outlined in the next section has a reduced form VARMA representation and thus relates to the TVP-VAR literature. In contrast to the TVP-VAR literature we will use a small scale macroeconomic model to decompose output, inflation and unemployment into their stochastic trend and business cycle gap components, with the latter being linked through the Phillips curve and Okun's law. This allows us to analyze more directly potential structural changes in the innovation variances of unobserved variables such as the output gap or potential output and potential time variation in the parameters governing the relation among them.

A common feature of the literature investigating structural change is that model uncertainty is mostly ignored. Time variation is typically modeled through discrete breaks or allowing parameters to change gradually by specifying them as

[1] An alternative version of Okun's law relates the change in the unemployment rate to output growth. This framework, however, rests on the restrictive assumption of a constant natural rate of unemployment and a constant growth rate of potential output.