Research in Economics 70 (2016) 281–303

Contents lists available at ScienceDirect

Research in Economics

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

Measuring business cycles with structural breaks and outliers: Applications to international data ☆

Pierre Perron [a], Tatsuma Wada [b]

[a] Department of Economics, Boston University, 270 Bay State Road, Boston MA02215, United States
[b] Faculty of Policy Management, Keio University, 5322 Endo, Fujisawa, Japan

ARTICLE INFO

Article history:
Received 2 November 2015
Accepted 1 December 2015
Available online 24 December 2015

Keywords:
Trend-cycle decomposition
Unobserved components model
International business cycle
Non-Gaussian filter

ABSTRACT

This paper first generalizes the trend-cycle decomposition framework of Perron and Wada (2009) based on unobserved components models with innovations having a mixture of normals distribution, which is able to handle sudden level and slope changes to the trend function as well as outliers. We investigate how important are the differences in the implied trend and cycle compared to the popular decomposition based on the Hodrick and Prescott (HP) (1997) filter. Our results show important qualitative and quantitative differences in the implied cycles for both real GDP and consumption series for the G7 countries. Most of the differences can be ascribed to the fact that the HP filter does not handle well slope changes, level shifts and outliers, while our method does so. Then, we reassess how such different cycles affect some so-called "stylized facts" about the relative variability of consumption and output across countries.

1. Introduction

Studies of business cycles have been one of the most important and attractive fields in macroeconomics. Since, at least Burns and Mitchell (1946), a variety of methods have been utilized to measure business cycle, thereby inspiring theoretical models that explain the features of the business cycles; alternatively, models are often evaluated on how well they mimic the characteristics of the business cycles that are observed in the data. The seminal work of Burns and Mitchell (1946) initiated the modern study of business cycle measurement. However, subsequently researchers adopted a different approach focusing more on easily applicable mechanical methods that obviate subjective evaluations. A major reason why economists have focused on this measurement issue is that most macroeconomic models pertain to business cycles or cyclical component. Faced with trending data, there is accordingly a need to separate the trend and the cycle.

Popular decomposition methods include, but are not limited to: the Beveridge and Nelson (1981) decomposition based on ARIMA models (Campbell and Mankiw, 1987; Watson, 1986; Cochrane, 1988, for example); the Unobserved Components models (Clark, 1987; Morley et al., 2003; hereafter UC models); the Hodrick and Prescott (1997) (hereafter HP) filter; and the Band-Pass filter (Baxter and King, 1999).

☆ This paper has been circulated under the title "An Alternative Trend-Cycle Decomposition Using a State Space Model with Mixtures of Normals: Specifications and Applications to International Data." We are grateful to James Morley, Charles Nelson, Tara Sinclair and seminar participants at the 11th World Congress of the Econometric Society, Purdue and Simon Fraser Universities, the Federal Reserve Banks of Dallas and Richmond, the Society for Nonlinear Dynamics and Econometrics Annual Meeting at Washington University for their useful comments.

E-mail addresses: perron@bu.edu (P. Perron), twada@sfc.keio.ac.jp (T. Wada).

http://dx.doi.org/10.1016/j.rie.2015.12.001
1090-9443/

Recently, Perron and Wada (2009) showed the importance of accounting for structural changes in the trend function of a time series when performing a trend-cycle decomposition. They considered the US real GDP series and argued that once a change in the slope of the trend function is allowed in 1973:1, standard unobserved components models and the Beveridge–Nelson decomposition deliver the same trend and cycle, the trend being a simple piecewise deterministic linear function. They also proposed a generalized unobserved components model where the errors affecting the slope of the trend function are drawn from a mixture of normals distribution.[1] This permits sudden changes in the slope occurring occasionally at dates that need not be pre-specified but which are the outcome of the smoothed trend estimate. Notably, Luo and Startz (2013) recently confirmed Perron and Wada's (2009) finding using a Bayesian methodology.

While a number of previous studies have considered allowing for a change in the slope of the trend within the context of UC models, e.g., Mitra and Sinclair (2012) for the G7 countries, in our view allowing for the possibility of changes in only the slope of the trend function is insufficient. As discussed in Section 2, when dealing with real GDP series for the G7 countries, one is also faced with the problems of level shifts and severe outliers. Our aim is, therefore, first to generalize the trend-cycle decomposition framework of Perron and Wada (2009) and extend their algorithm to estimate the resulting structural models. Secondly, we wish to investigate how important are the differences in the implied trend and cycle for the various countries compared to other methods. Since, in empirical macroeconomic analyses, the most frequently used detrending procedure is the HP filter, we shall restrict our comparative analysis to our detrending procedure and the HP filter. Our results will show important qualitative and quantitative differences in the implied cycles for both real GDP and consumption series for the G7 countries. As also pointed out by Dueker and Nelson (2006), who compared their method which uses a latent business-cycle index that is negative during recessions and positive during expansions based on the NBER classification, most of the differences can be ascribed to the fact that the HP filter does not handle well slope changes, level shifts and outliers, while our method does so. Hence, our results first lead to a different picture of the cyclical component of important macroeconomic time series. Third, we assess how such different cycles affect some so-called "stylized facts" about the relative variability of consumption and output across countries. Our results show again some important differences. In particular, we find that (i) the volatility of consumption is not necessarily smaller than that of output, (ii) compared to the results using the HP filter, there are more cases for which cross-country correlation in consumption is higher than that in output; and (iii) unlike the majority of previous studies, including Canova et al. (2007) and Stock and Watson (2005), there is not much evidence for the hypothesis that the characteristics of countries' business cycles can be categorized into three groups of countries, namely, European (France, Germany, and Italy), Japan, and English speaking countries (Canada, UK and US).[2]

The plan of the paper is the following. Section 2 motivates the subsequent analyses by looking at the salient features of real GDP series for the G7 countries. We establish the theoretical framework for the trend-cycle decompositions and the selection of models for each country in Section 3. Section 4 presents the results for the trend-cycle decomposition of the real GDP and consumption series or the G7 countries and compare the results to those obtained with an HP filter. Section 5 reassesses the findings about important measures of cyclical movements in output and consumption across the G7 countries using our trend-cycle decomposition, with emphasis on the relative volatilities of the cyclical components of output (real GDP) and consumption, and the cross-country correlations in these components. Section 6 offers brief concluding comments. An appendix contains technical details.

2. Motivation

Figs. 1 and 2 present the seasonally adjusted (log) real GDP and real consumption series for the G7 countries using postwar quarterly series from 1960.I through 2011.IV. The data[3] are from the Organization for Economic Co-operation and Development's (OECD) *Quarterly National Accounts*. These graphs reveal a number of interesting features. First, most countries show a decline in the rate of growth occurring near 1973. This is a feature that has received a lot of attention. For example, Perron (1989) argues that once one allows for a change in the slope of the trend function in 1973:1, one can reject the hypothesis that the US real GDP series contains a unit root (see Perron, 1997, for evidence pertaining to real GDP series for the G7 countries). Also, Bai et al. (1998) estimate a multivariate model of the growth rates of real GDP for the G7 countries imposing a common break. They find statistical evidence for a change in mean with a 90% confidence interval that covers the period 1972:2–1975:2. More evidence is presented in Perron and Yabu (2009) who find a statistically significant change in the slope of the trend function for all countries allowing the noise component to be stationary or to have an autoregressive unit root. In all such studies the change is modelled as being sudden (i.e., a structural change at some date).[4]

[1] They also consider such a distribution for the shock to the cyclical component to allow different variances in expansions and recessions.

[2] Doyle and Faust (2005) considered structural breaks in the growth rates of G7 output, consumption, and investment. They also document a reduced cross-country correlation within the groups.

[3] Real GDP data are: Gross Domestic Product, Expenditure approach, Millions of national currency, volume estimates, OECD reference year, annual levels, seasonally adjusted (VOBARSA). For consumption, we use Private final consumption expenditure, millions of national currency, volume estimates, OECD reference year, annual levels, seasonally adjusted (VOBARSA); hence durable, non-durables and services are included.

[4] See Perron (2006) for a comprehensive survey related to time series models with structural breaks.