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On business cycle fluctuations in USA macroeconomic time series

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ABSTRACT

This study employs eighteen USA macroeconomic time series variables to investigate possible existence of asymmetries in business cycle fluctuations in the series. Detection of asymmetric fluctuations in economic activity is important for policymakers since effective monetary policy relies on asymmetric business cycle fluctuations in all the series. The asymmetric deviations from the long-term growth trend in each of the series are modeled using regime switching models and artificial neural networks. The results based on nonlinear switching time series models reveal strong evidence of business cycle asymmetries in most of the series. The results based on in-sample approximations from artificial neural networks show statistically significant evidence of asymmetries in all the series. Similar results are obtained when jackknife out-of-sample approximations from artificial neural networks are used. Thus, the study results show statistically significant evidence of asymmetries in all the series which indicates that business cycle fluctuations in the series are asymmetric, thus alike. Therefore, the impact of monetary policy shocks on the output and the other macroeconomic variables can be anticipated using nonlinear models only. The results on asymmetric business cycle fluctuations in real GDP are in line with recent studies but in sharp contrast with Balke and Fomby (1994).

1. Introduction

A wide body of empirical research has established that asymmetries prevail in business cycle fluctuations in economic activity (see Neftci, 1984; Beaudry and Koop, 1993; Brunner, 1997; Potter, 1995; Ramsey and Rothman, 1996; Andreano and Savio, 2002; Kiani and Bidarkota, 2004; Kiani, 2005; and Morley and Piger, 2012 among others). Nevertheless, an important empirical and policy related question has not been answered yet. For instance, a policymaker would be interested in stabilizing the economy using monetary policy shocks to affect output. However, Blanchard and Watson (1986) showed that business cycle fluctuations in USA macroeconomic time series are not alike. Therefore, to stabilize the economy it would be challenging for the policymakers to predict the impact of a monetary policy shock on macroeconomic variables using either linear or nonlinear models. Consequently, the present study further explores on the concept and the scope of the asymmetric business cycle fluctuations in all the series in the economy.

A business cycle is a recurrent phenomenon that consists of a cyclical expansion followed by contraction, and recovery in economic activities at the same time (Burns and Mitchell, 1946). While a business cycle is retrospectively defined across many sectors and series, fluctuations in aggregate output or GDP are central and can be used as a reference point for evaluations across various series. The classical techniques of business cycle analysis were developed by researchers at the National Bureau of Economic Research (Burns and Mitchell, 1946; Mitchell, 1927; Mitchell and Burns, 1938). McQueen and Thorley (1993) reveal that USA business cycle is characterized by sharp troughs and round peaks. Balke and Wynne (1995) find out that the shape of the business cycle is concave during expansion and linear during the contractions. Galvao (2002) showed existence of contraction and expansion in the shape of the US business cycle.

Asymmetries demonstrate that the span of the positive part of a business cycle is more than that of the span of its negative portion. Similarly, the amplitude of the contraction of the business cycle is greater than that of the expansion. Thus, using a nonlinear model an impulse response function generated from a unitary positive shock will be different than that of the impulse response function generated from a negative shock of equal magnitude making the two parts of the cycle dissimilar or asymmetric (Beaudry and Koop, 1993). However, a number of researchers maintain that asymmetries reported in various studies are due to the presence of outlier in the data series. In this context Blanchard and Watson (1986) found evidence of outlier in the GNP series. Scheinkman and LeBaron (1989) presented a weak evidence of asymmetries in the series once outliers were taken into account. Similarly, Tsay (1988) reveals that the hypothesis of a symmetric business cycle could be rejected because of the presence of outlier in the series. Likewise, Balke and Fomby (1994) investigated fifteen USA macroeconomic time series but they were unable to demonstrate statistically significant evidence of asymmetries in most of the series they studied, showing that business cycle fluctuations are not alike.

Asymmetries invalidate the measure of the persistence of monetary policy or any other shock on output that is based on linear models when the underlying data generating process of the series is nonlinear.

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Therefore, it is imperative to identify if business cycle fluctuations in all the series in the economy are asymmetric[1] otherwise policymakers would not be able to forecast the impact of a monetary policy or any other shock on the output. To fill this gap, the present study seeks to determine if business cycle fluctuations in 18 USA macroeconomic time series[2] are asymmetric making the business cycle fluctuations in macroeconomic time series similar or alike.

The present study uses alternate regime switching time series models that encompass features to account for conditional heteroskedasticity, long memory and non-normality that may be present in the series. However, Andreano and Savio (2002) who tested asymmetric business cycle fluctuations in G7 countries using Markov Switching models were unable to detect presence of asymmetries in three out of seven GDP series employed. Similarly, Kiani and Bidarkota (2004) also tested for the presence of asymmetries in G7 countries but they were also unable to detect asymmetries in two out or seven series used. This necessitated using artificial neural networks (ANN) that are highly flexible functional form of nonparametric nonlinear models for detecting possible existence of asymmetric business cycle fluctuations in all the series. ANN are able to fit any time series data without taking into account the underlying data generating process of the series. Therefore, in-sample as well as jackknife out-of-sample predictions from ANN are also employed for testing possible existence of asymmetries in business cycle fluctuations in all the series. Neural networks have been employed by Kaun and White (1994) and Swanson and White (1995, 1997) in economic time series, Qi and Madala (1999) in stock market predictions, Kiani and Kastens (2008) in exchange rates forecasting, and Kiani (2005), in business cycles. The results based on forecasts obtained from alternate regime-switching models show statistically significant evidence of business cycle asymmetries in most of the series. Moreover, the results based on in-sample as well as jackknife out-of-sample forecasts from artificial neural networks reveal statistically significant evidence of business cycle asymmetries in all the series. Therefore, linear models cannot be used for forecasting the impact of monetary policy or any other shock on the output or any of the USA macroeconomic time series.

The remainder of the paper is organized as follows. Section 2 provides a brief description of the empirical models employed. Section 3 details data sources and specification search. Section 4 presents symmetry tests, and other hypotheses of interest, and Section 5 shows empirical results on hypothesis tests. Finally, Section 6 summarizes the conclusions of the study.

2. Empirical models

2.1. Nonlinear switching time series models

Nonlinear switching time series models are employed for testing possible presence of asymmetries in conditional mean dynamics of eighteen USA macroeconomic time series. These models are of four types. Model1 is the most general model which incorporates long memory, conditional heteroskedasticity, and stable distribution. Restricting long memory in model1, gives model2, imposing homoskedasticity in model2 generates model3, and finally, restricting the errors in model3 to come from a stable distribution yields model4.

2.1.1. SETAR-switching model

The idea of multi-regime model dates back to Bacon and Watts (1971). Regime switching models assume that the relevant relationships within the regime are linear but possibly different across regimes. Tong (1978) proposed a threshold autoregressive (TAR) model wherein the regimes switch according to the observable past history of the system (Tsay 1983, Tsay, 1989). The TAR model approximates the data asymmetries by piecewise linear regimes. In case of threshold models, the regimes are given by a transition function that depends on an observed variable (Tong, 1990).

The self-exciting threshold autoregressive (SETAR) switching model was proposed by Potter (1995). The switch between the two regimes in this model is managed by the restrictions that are defined in terms of the observed series (i.e.y_t). Potter employed a single restriction on the observed series setting $\Delta y_{t-l} > r$, where y_t is an observed series like real GDP or any other macroeconomic time series, l is a delay parameter, and r is a threshold parameter. The delay parameter l is an integer satisfying $0 \le l \le p$ where, p is the number of lags in each regime. In this study the delay parameter l is set equal to 2 which is in line with previous studies including Potter (1990, 1993) and Hansen (1996) among others. This study uses a version of the model due to Kiani and Bidarkota (2004) for testing business cycle asymmetries in all the series where errors are assumed to follow a more general stable distribution. Thus, the most general SETAR-switching model employed in this study is shown in the following equations:

$$\left(1-\phi_{1i}L-\phi_{2i}L^2-,\ \ldots\ldots,\ -\phi_{pi}L^p\right)(1-L)^d(\Delta y_t-\mu_i) = \varepsilon_t \varepsilon_t | I_{t-1} \sim z_t \gamma c_t,\ \ z_t \sim i.i.d.S_\alpha(0,1) \tag{2.1a}$$

$$c_t^\alpha = b_1 + b_2 c_{t-1}^\alpha + b_3 |\varepsilon_{t-1}/\gamma|^\alpha \tag{2.1b}$$

where, $i = 1, 2$, and the index i represents the two regimes in the model, and p denotes the number of auto regressive (AR) terms in it. Eq. (2.1a) represents a SETAR-switching model, whereas Eq. (2.1b) incorporates the GARCH specification of this model. The switch between the two regimes is governed by the switching parameter Δy_{t-2}. Only one regime is obtained when $\Delta y_{t-2} > 0$, however, when $\Delta y_{t-2} \le 0$, the model will have two distinct regimes.

A stable distribution is used to capture outlier in the series. A random variable X will have a symmetric stable distribution $S_\alpha(\delta, c)$ when its log characteristic function can be stated as $\ln\ E[\exp(iXt)] = i\delta t - |ct|^\alpha$. Here, α is a characteristic exponent that governs the tail behavior, c is the scale parameter and δ is the location parameter. Small values of α display thicker tails and when $\alpha = 2$ a normal distribution results. In Eq. (2.1b) when the value of α is equal to 2 a normal GARCH (1, 1) process results in conditional volatility. A detailed discussion on stable distribution is given in Kiani and Bidarkota (2004).

2.2. Artificial neural networks

Artificial neural networks (ANN) are powerful computational procedures that learn from examples and generalize these learnings for solving complex functional form of nonlinear models (Reilly and Cooper, 1990). ANN are nonlinear, nonparametric statistical methods that are independent of the distributions of the underlying data generating processes (White, 1989). Hornik et al. (1989) demonstrate that ANN are able to approximate any continuous function with a desired level of precision. Being nonlinear ANN can be fit to any time series data that are generated by a nonlinear propagation mechanism. However, ANN have come under heavy criticism because of their tendency to overfit the data. This criticism is dealt with by a careful construction of an

[1] Here we are interested in whether business cycle fluctuations in all the series in economy are either asymmetric or symmetric without considering their span and amplitude. However, it may be mentioned that duration of expansions in the US economy have been more than the span of the recessions showing that business cycles are asymmetric. Empirical evidence shows that the impact of an impulse response generated from a negative monetary policy or any other shock to output lasts for up to 10 quarters. However, an impulse response function generated from a positive shock of an equal magnitude persists for a longer period (Beaudry and Koop, 1993).

[2] Real gross national product, consumption, real gross domestic product (*GDP*), GDP deflator, consumer price index, industrial production, gross domestic investment, gross investment, unemployment rats, employment rate non-industrial civilians, hourly compensation, monetary base, narrow money supply $M1$, relatively broader money supply $M2$, quasi money, USA bond, AAA bond yield, and S & P 500 stock prices.