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Measuring business cycles: Empirical Mode Decomposition of economic time series

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HIGHLIGHTS

- We presented empirical mode decomposition as time-series decomposition technique.
- We compared empirical mode decomposition with well-known time-series filters.
- The results are similar to results obtained by time-series filters.
- Our paper is a sequel to the paper by Motohiro Yogo (Economics Letters, 2008).

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ABSTRACT

This paper continues discussion on the issue of time series decomposition by presentation of the Empirical Mode Decomposition technique. This technique outperforms well-known time-series filters by providing a deeper insight into the structure of time series.

1. Introduction

This paper builds on a series of papers that present time series decomposition techniques. It could be considered as a sequel to the paper by Yogo (2008), which introduced wavelet analysis as an economic time series decomposition technique. The aim of this paper is to present another useful technique for the analysis of fluctuations of economic time series: Empirical Mode Decomposition (EMD). This technique was first explained in the seminal paper by Huang et al. (1998). As with Wavelet Analysis, EMD can closely resemble series filtered by approximate filters (Baxter and King, 1999 or/and Hodrick and Prescott, 1997) and, therefore, could be considered as an alternative to band-pass filtering. However, EMD also provides a better insight into the structure of time series, which is, as already pointed out by Yogo (2008), 'useful for capturing the changing volatility of the business cycle'. Since this paper builds on the work by Yogo (2008), it provides results that are directly comparable with the results obtained by his appliance of wavelet analysis.

The rest of the paper is organized as follows. First, a brief overview of EMD is presented. Then the application and significance of the EMD method is demonstrated on US real GDP data, while comparing the obtained results with the results obtained by other time-series filtering techniques. Finally, some advantages and disadvantages of the application of EMD are briefly discussed in the conclusion.

2. EMD: a brief overview

EMD represents a decomposition technique by which almost any time series could be decomposed into a finite set of mono-component functions, called Intrinsic Mode Functions (IMFs). The term 'mono-component' means that the functions do not resemble a pattern of riding waves (Huang et al., 1998). Theoretically speaking, any single-extracted cycle series should not be contaminated

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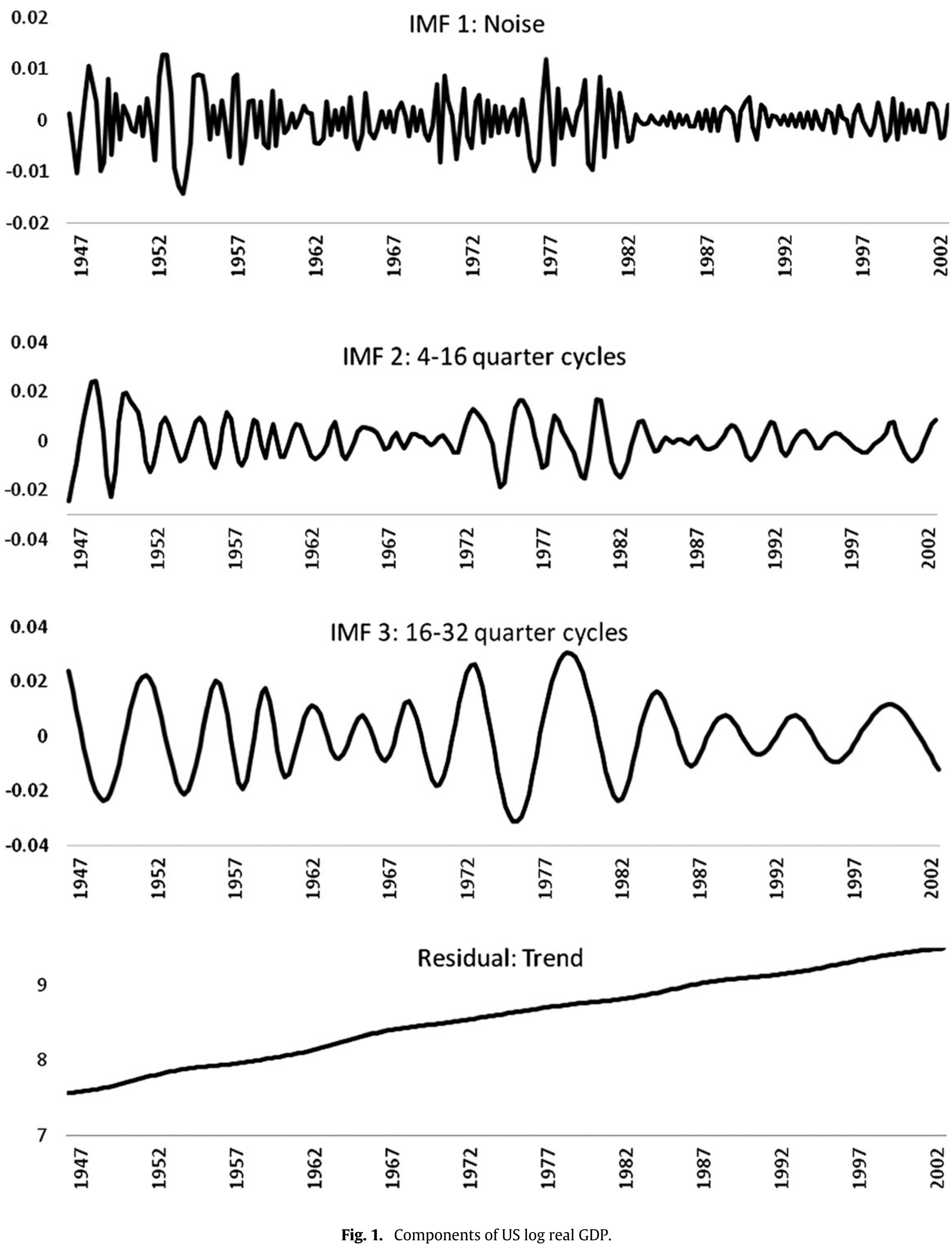

Fig. 1. Components of US log real GDP.

by any other cycle or noise. Consequently, an IMF should satisfy the two following conditions:

(1) Must have zero mean;
(2) The number of its extrema (minima and maxima) and the number of zero crossings can differ only by one.

By satisfying the aforementioned conditions, it is implied that an IMF is, in fact, approximately symmetric and has all maxima positive and all minima negative. The final residual is either monotonic or constant. If it is monotonic, then it represents the trend of time series. If it is constant, then the trend is represented by the last extracted IMF.

The detailed algorithm of EMD can be found in Huang et al. (1998); however, those who are unfamiliar with the technique should first read (Flandrin et al., 2004), which is easier to comprehend. The essential steps of the algorithm are as follows:

(1) Identification of local extrema (minima and maxima) of the time series $x(t)$;
(2) Interpolation of envelopes around local minima and maxima with cubic splines ($e_{\min}(t)$ and $e_{\max}(t)$);
(3) Calculation of mean of envelopes:

$$m_1(t) = \frac{[e_{\min}(t) + e_{\max}(t)]}{2}. \quad (1)$$