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A note on the uncertain trend in US real GNP: Evidence from robust unit root tests

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Abstract

In this paper, we test the presence of stochastic trend in long series of US real GNP measured by Balke and Gordon (1989) and Romer (1989), using unit root tests robust against breaks and outliers. We apply two recent robust unit root tests proposed by Cavaliere and Georgiev (2009) and Lima and Xiao (2010), for which critical values are adapted to the small sample size and using optimal lag selection methods. The former is improved by selecting optimally GLS detrending parameter to make the test in small samples powerful. We obtain mixed results on the presence of a unit root in the GNP and GNP per capita series on the 1869-2007 period. Even if we cannot conclude on the pre-1929 period, probably because of the reconstruction on the data, we show that the US real GNP series is characterized by a deterministic trend on the post-1929 period.

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1. Introduction

In spite of numerous studies, the question of deterministic versus stochastic trend in long-term US GNP remains open. A lot of effort has been dedicated to this question in the macroeconometrics literature. Whether the time series can be modeled as stationary fluctuations around a deterministic trend or as difference stationary process is an important issue for many reasons, mainly for economic forecasts, shock identification and regression analysis. A number of studies have examined the long spans of data on US real GNP over the period 1875-1993 with mixed conclusions (e.g., Diebold and Senhadji, 1996; Cheung and Chinn, 1997; Newbold et al., 2001).

This lack of consensus can be explained by infrequent but relevant events, which can be considered as outliers or structural breaks in the data series and can have important effects on the unit root tests (e.g., Franses and Haldrup, 1994; Hoek et al., 1995; Burridge and Taylor, 2006). The mixed conclusion on the trend in real GNP can be also caused by the period of turmoil experienced from 1929 to 1949 due to the Great Depression and World War II (e.g., Newbold et al., 2001; Papell and Prodan, 2004). Indeed, Balke and Fomby (1991), Murray and Nelson (2000) and Darné (2009) showed the presence of outliers for annual GNP series during this period. Therefore, various techniques have been employed to take into account this phenomenon, such as unit root tests based on intervention analysis (Balke and Fomby, 1991), unit root tests with unrestricted (Murray and Nelson, 2000) or restricted (Papell and Prodan, 2004) structural breaks, unit root tests on the outlier-adjusted data (Darné, 2009). However, these techniques have some drawbacks: unit root tests based on intervention analysis are very sensitive to the specification of the alternative model (Montañés et al., 2005); the unit root tests with endogenous structural breaks are sensitive to the number of breaks taken into account, the date of the break (Kim et al., 2000), and the specification of the model (Sen, 2003); the size performance of unit root tests on outlier-corrected data has been investigated but not its power performance.

Considering these drawbacks, we propose to use an alternative approach that is based on robust statistics to assess the presence of stochastic trend in long series of US real GNP. We apply two recent robust tests: the partially adaptive ADF test proposed by Lima and Xiao (2010) and the quasi maximum likelihood ADF test developed by Cavaliere and Georgiev (2009). For the latter we improve its power in small samples by selecting optimally GLS detrending parameter, as suggested by Broda et al. (2009). We also use critical values adapted to the small sample sizes of the GNP series of interest. Further, research by Hall (1994) and Ng and Perron (1995, 2001) shows that the use of too short lag lengths lowers power for ADF tests and makes DF-GLS tests oversized. They recommend a general-to-specific procedure for ADF tests and a modified Akaike information criterion for DF-GLS tests. Therefore, we employ these lag selection techniques for the robust versions of ADF and DF-GLS tests.

The remainder of this paper is organized as follows: Section 2 describes briefly the two robust unit root tests. Section 3 describes the empirical results on the US GNP series. Section 4 concludes.

2. Robust unit root tests

Hoek et al. (1995) suggested to consider the maximum likelihood M estimator based on the Student-t distribution (MLT estimator). Robust unit root test based on the MLT estimator has been extensively proposed in the literature (e.g., Lucas, 1995a, 1995b; Thompson, 2004) in the framework of the unit root test. The basic idea is to base inference on a Student-t error distribution rather than the usual Gaussian distribution. Xiao and Lima (2005) extended this approach by selecting the degrees of freedom using a data-dependent procedure. They consider the partially adaptive estimator based on the family of Student-t distributions, introduced by Potscher and Prucha (1986), for the ADF regression, giving the *PADF* statistic test. This tends to give correct critical values because it approximates the true distribution by the data distribution.

Cavaliere and Georgiev (2009) proposed a robust quasi maximum likelihood (QML) approach for the ADF regression.[1] They suggested a sequential procedure for the linear trend case by applying the robust QML approach on the GLS detrended series, as in Elliott and al. (1996) with their DF-GLS test, giving the $ADF\text{-}GLS^Q$ statistic test. The GLS detrending depends on a parameter $\alpha = 1 - (c/T)$, where c is fixed and T is the sample size. Elliott et al. (1996) report that choosing $c = -13.5$ for the trend linear case leads to tests with asymptotic power curves (asymptotic power envelopes equal to 0.5). Nevertheless, Broda et al. (2009) show that an inappropriate choice of c can lead to less powerful tests. These authors proposed a procedure which numerically determines values of c that minimize a weighted power loss criterion for each test and sample size, and it is powerful in small samples.

3. US Real GNP

3.1. 1869–2007

Diebold and Senhadji (1996) constructed four annual US real GNP data spanning the period 1869 to 1993 as in Diebold and Senhadji (1996), i.e. GNP-BG, GNP-R, GNP-BGPC and GNP-RPC, based on whether measures from Balke and Gordon (1989) (BG) or Romer (1989) (R) were employed or whether the GNP was expressed in per capita (PC) form. Diebold and Senhadji (1996) created these real GNP series by splitting the 1869-1929 real GNP series of Balke and Gordon (1989) or Romer (1989) to the 1929-1993 real GNP series reported by the National Income and Product Accounts by the U.S. Department of Commerce, measured in billions of 1987 dollars. We extend Diebold and Senhadji's data through 2007. The logarithmic transformation is applied to the data.

We apply the procedure of Broda et al. (2009) to determine the appropriate choice of c depending on the sample size. We obtain $c = -12.5$ for our full sample size (1869–2007) with $T = 139$. For the unit root test of Cavaliere and Georgiev (2009) we use the finite-sample critical values computed by Cook (2006) for various values of c. For $c = -12.5$, the critical values at the 1%, 5% and 10% levels of significance are -3.60, -3.00 and -2.71, respectively.

The results of the robust unit root tests are given in Table 1. We perform unit root tests using standard lag (k) selection techniques. We use the general-to-specific (GS) strategy of Hall (1994) and Ng and Perron (1995), which consist in starting with a maximum value of k chosen *a priori*, deleting lags sequentially until significance level of 0.10, for the PADF test, and the modified Akaike information criterion (MAIC) of Ng and Perron (2001) for the $ADF\text{-}GLS^Q$ test. Here, we set $k_{max} = 8$.

[1]Cavaliere and Georgiev (2009) showed in their Monte Carlo simulations that the robust QML approach is more powerful than the robust method proposed by Lucas (1995a, 1995b).

The unit-root null hypothesis is rejected for GNP-R, GNP-BG and GNP-BGP at the 5% level by the PADF test, but not by the $ADF\text{-}GLS^Q$ test. Both tests give the same conclusion only for GNP-RPC with the rejection of the unit-root hypothesis. We thus can not conclude on the characterization of the long-term US real GNP trend. A possible explanation of this finding can be the pre-1929 period (1869–1928), where the GNP series have been reconstructed. Therefore, we re-examine the unit-root null hypothesis on the pre-1929 and post-1929 periods.

3.2 1869–1928

The US GNP series on the pre-1929 period (1869–1928) have been differently constructed by Balke and Gordon (1989) and Romer (1989). Balke and Gordon (1989) used more indicators than Romer (1989) to backcast GNP, and this procedure tends to accentuate the fluctuations of the output and therefore the series is less smooth for the period 1869-1929.[2]

For the Cavaliere-Georgiev unit root tests, we obtain $c = -11.6$ as optimal parameter for the sub-sample, with $T = 60$. The critical values at the 1%, 5% and 10% levels of significance are -3.58, -2.98 and -2.69, respectively. The results displayed in Table 1 show that for the pre-1929 GNP data, the unit-root hypothesis is not rejected for GNP-BG and GNP-R by both tests, except GNP-R by the PADF test, whereas this hypothesis is rejected for the same series in per capita form GNP-RPC and GNP-BGPC. This difference between GNP in per capita form or not can be explained by the fact that use of per capita GNP eliminates a possibility of non-stationarity in GNP time series resulting from inflation and population growth. Another explanation suggested by Cheung and Chinn (1997) is that the trend-stationarity result for the historical annual data is driven by the data-construction procedure. Jaeger (1990) show that segmented linear interpolation may be responsible for the finding of a stochastic trend in prewar US GNP.[3] Further, Stock and Watson (1986) conjecture that linear interpolation may cause the difference between the GNP shock persistence of prewar and postwar series. This finding raises the question about the relevance to use reconstructed data for the econometric analysis and on the conclusions resulting from this.

3.3. 1929–2007

The US GNP series on the post-1929 period (1928–2007) are the same for the series constructed by Balke and Gordon (1989) and Romer (1989). The results for GNP and GNP per capita are given in Table 1. The unit-root hypothesis is rejected by both tests at 10% level for the GNP, and at 1% level for the GNP in per capita form. We thus can conclude that the post-1929 US real GNP series is characterized by a deterministic trend.

4. Conclusion

This paper tested the presence of stochastic trend in long series of US real GNP measured by Balke and Gordon (1989) and Romer (1989), using unit root tests robust against breaks and outliers. We applied two recent robust unit root tests proposed by Cavaliere and Georgiev (2009)

[2]Darné (2009) found more shocks in the data sets constructed by Balke and Gordon (1989) than those based on Romer (1989) for the period 1869-1929. Further, Murray and Nelson (2000) suggested measurement errors in the reconstructed series.

[3]From Monte Carlo experiments Jaeger (1990) suggests that segmented linear interpolation reduces the size of shock persistence in a difference stationary series. Dezhbakhsh and Levy (1994) also show that the interpolated series may exhibit more shock persistence than the original trend stationary series.

and Lima and Xiao (2010), for which critical values are adapted to the small sample size and using optimal lag selection methods. The former was improved by selecting an optimally GLS detrending parameter to make the test powerful in small samples. We obtained mixed results on the presence of a unit root in the GNP and GNP per capita series, and thus can not conclude on the characterization of the long-term US real GNP trend.

We re-examined the pre-1929 GNP data, i.e. the period where the Balke-Gordon and Romer series are differently constructed, and the post-1929 GNP data, i.e. the period where both series are the same. For the pre-1929 period, the unit-root hypothesis was not rejected for the GNP series proposed by Balke-Gordon and Romer, but this hypothesis was rejected for the same series in per capita form. This difference can be explained by the data-construction procedure employed for the pre-1929 GNP series. This finding raises the question of the relevance to use reconstructed data for the econometric analysis and on the conclusions resulting from this. Finally, for the post-1929 period, the US real GNP series is characterized by a deterministic trend.

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Table 1: Results of robust unit root test for annual US GNP series .

Data series	t-stat	1869–2007	k	1869–1928	k	1929–2007	k
GNP-R	$ADF\text{-}GLS^Q$	-2.178	MAIC=4	-2.167	MAIC=0	-2.967***	MAIC=10
	$PADF$	-3.381*	GS=1	-3.983*	GS=6	-3.090***	GS=10
GNP-BG	$ADF\text{-}GLS^Q$	-2.499	MAIC=5	-2.378	MAIC=0		
	$PADF$	-4.171*	GS=1	-2.446	GS=1		
GNP-RPC	$ADF\text{-}GLS^Q$	-4.498*	MAIC=4	-3.099**	MAIC=0	-5.250*	MAIC=1
	$PADF$	-3.195*	GS=1	-3.605*	GS=3	-5.291*	GS=8
GNP-BGPC	$ADF\text{-}GLS^Q$	-2.347	MAIC=5	-3.280**	MAIC=0		
	$PADF$	-3.859*	GS=1	-3.610*	GS=0		

Notes: *, ** and *** indicate rejection of the unit-root null hypothesis at the 1%, 5% and 10% level of significance, respectively. The variable are the log of Romer's (1989) gross national product (GNP-R), the log of Balke and Gordon's (1989) gross national product (GNP-BG), the log of Romer's (1989) gross national product per capita (GNP-RPC), and the log of Balke and Gordon's (1989) gross national product per capita (GNP-BGPC).