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Response of inflation to shocks: New evidence from Sub-Saharan African countries

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ABSTRACT

In this paper, we investigate whether or not the inflation rate of 17 Sub-Saharan African countries can be modelled as a stationary process. We achieve this goal through using univariate and panel stationarity tests for data over the period 1966 to 2002. We use the Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) univariate test and allow for multiple structural breaks. We find that except for Burkina Faso, Burundi and Gambia, the inflation rate is stationary for the rest of the 14 countries. We then apply the panel version of the KPSS test, developed by Carrion-i-Silvestre et al. (2005), which accounts for multiple structural breaks. We find strong evidence of panel stationarity of the inflation rate. However, for a panel consisting of Burkina Faso, Burundi and Gambia, we could not find evidence that the inflation rate is stationary.

1. Introduction

From both policy and econometric modelling points of view, the knowledge on whether or not the inflation rate is stationary is imperative. A mean-reverting inflation rate implies that shocks to inflation will have a transitory effect on inflation whereas a non-stationary inflation rate implies that shocks to inflation will have a permanent effect. In addition, achieving price stability is a key aim of central banks. The inflation rate is an indicator of the success of monetary policy. This line of argument has been supported by, *inter alia*, Clarida et al. (1999), Goodfriend and King (2001), Huang and Liu (2005) and Woodford (2003), who contend that central banks should stabilise fluctuations in consumer price index inflation. It follows that whether or not the central bank is able to stabilise fluctuations in output can be gauged from knowledge on the integration properties of the inflation rate.

As Narayan and Narayan (2010) explain, from an econometric modelling point of view, whether or not inflation is stationary is crucial in model selection. For instance, when data (in our case, inflation rates) are stationary, a vector autoregressive (VAR) model can be estimated in levels. However, when data are non-stationary, extra care needs to be exercised to avoid spurious results. For instance, in the case that inflation rates contain a unit root, it is impossible to study a system of inflation rates using a VAR model. Non-stationary inflation rates demand a test for possible cointegration relationship(s). Assuming that one finds evidence for cointegration, then the conventional VAR model needs to be augmented with the one period lagged error correction term. This transformed model is referred to as the vector error correction model (VECM), which entails both short-run and long-run relationships, as opposed to the VAR model which only allows one to extract the short-run relationships (Narayan and Narayan, 2010). The lagged error correction term measures the speed of adjustment to equilibrium after a shock to the system: the speed of adjustment to restore equilibrium is crucial information for policy makers, allowing an understanding of the persistence of shocks.

A non-stationary inflation rate is a key consideration in estimating money demand functions, which states that demand for money depends upon a variable that reflects the level of transactions in the economy such as real income or wealth, and another variable that reflects the opportunity cost of holding money such as the inflation rate or the interest rate. Moreover, the expectations-augmented Phillips curve model, where wages and prices share a long-run relationship, and require inflation to be non-stationary and the Fisher hypothesis, where the nominal interest rate should move one-for-one with the expected inflation rate, require the inflation rate to be non-stationary.

In this paper, we examine whether or not the inflation rate for 17 Sub-Saharan African countries, namely Burkina Faso, Burundi, Democratic Republic of Congo, Cote Ivoire, Ethiopia, Gambia, Ghana, Kenya, Madagascar, Mauritius, Niger, Nigeria, Sierra Leone, South Africa, Swaziland, Tanzania, and Zimbabwe is characterised by a unit root. The goal of this paper is achieved in two steps. In the first step, we apply the univariate Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) version of the test to test the stationarity of the inflation rate. Our first innovation here is that we extend the KPSS test to allow

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for multiple structural breaks. Our second innovation is that we compute critical values at conventional levels of significance for each of the 17 countries by taking into account the revealed structural breaks.

In the second step, we apply the panel version of the KPSS test, developed by Carrion-i-Silvestre et al. (2005), that allows one to incorporate multiple structural breaks. Two aspects of this methodology are worth noting here. First, this KPSS panel structural break test is the only test that allows one to incorporate more than two structural breaks in the data series; thus, it is an advance over Im et al. (2005) and the time series versions of the test proposed by Narayan and Popp (2010), Lee and Strazicich (2003) and Lumsdaine and Papell (1997). Second, unlike the Im et al. (2005) panel test which specifies the null hypothesis as a non-stationary series, the KPSS panel structural break tests treat the null hypothesis as a stationary series.

Briefly foreshadowing our main results, we find that when we use the Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) univariate tests, allowing for multiple structural breaks, for Burkina Faso, Burundi and Gambia the inflation rate is non-stationary, while for the rest of the 14 countries it is stationary. When we apply the panel version of the KPSS test, which accounts for multiple structural breaks developed by Carrion-i-Silvestre et al. (2005), we find overwhelming evidence of panel stationarity of the inflation rate. However, we could not find evidence for stationarity of the inflation rate for a panel consisting of Burkina Faso, Burundi and Gambia.

We organise the balance of the paper as follows. In Section 2, we provide a brief review of previous literature on the unit root properties of the inflation rate. In Section 3, we discuss the KPSS univariate test with multiple structural breaks and the KPSS panel test with multiple structural breaks for stationarity of the data. In the penultimate section, we discuss the empirical results, and in the final section, we conclude.

2. A brief overview of the literature

The aim of this section is to undertake a brief review of the key features of the literature on the unit-root hypothesis of the inflation rate. In terms of key features, this is how the literature has evolved. First, studies have considered a range of data frequencies, covering annual, quarterly, and monthly data (see Taylor and Sarno, 1998 and the studies cited there), which are apparently the most popular data frequencies used in this literature.

Second, studies have used both time series (see, *inter alia*, Charemza et al., 2005; Culver and Papell, 1997) and panel data unit root tests (see, *inter alia*, Lee and Wu, 2001; Narayan and Narayan, 2010) to model mean reversion in the inflation rate. Within time series studies, some (Garcia and Perron, 1996; Malliaropulos, 2000) have used structural break unit root tests; some have considered nonlinear unit root tests (Henry and Shields, 2004); and some studies (Arize et al., 2005) have also used fractional integration tests to search for mean reversion in the inflation rate. A relatively recent study by Narayan and Popp (2011) considers a structural break seasonal unit root test for modelling mean reversion in the inflation rate. The main message here is that from a methodology point of view the subject of mean reversion in the inflation rate has accumulated a rich body of literature.

Third, in terms of results, the main conclusion seems to be that univariate tests (without structural breaks) generally fail to find strong evidence of mean reverting inflation rates—this is true for both developing and developed countries. By contrast, when the literature has accounted for structural breaks, the evidence in favour of a mean reverting inflation rate has improved and has become even better when more than one structural break unit root model is used. Finally, the evidence from panel data unit root models suggests the strongest evidence of a mean reverting inflation rate. This is hardly surprising. The source of power to reject the unit root null, when one moves from time series unit root tests without structural breaks to models with structural breaks is the accounting of structural breaks themselves (see Narayan and Popp, 2010, 2013). Therefore, that the literature has found greater evidence of a mean reverting inflation rate when subjecting the inflation data to structural break unit root tests is, to a large extent, expected. The second source of power to reject the unit root null comes from sample size. As one moves from time series to panel data unit root models, the immediate gain is in sample size. For this reason alone, panel data unit root models are popular and this popularity is reflected in the strong evidence of panel mean reversion in the inflation rate as documented by the literature.

3. Stationarity test with multiple structural breaks

In this section, we describe the test for the null hypothesis of stationarity that allows for at most five structural breaks in panel data suggested by Carrion-i-Silvestre et al. (2005). Our motivation for choosing a test where the null hypothesis is stationarity of the series as opposed to it being a unit root process is that Bai and Ng (2004) argue that this setup represents a more natural characterisation of many of the economic problems. The Carrion-i-Silvestre et al. (2005) technique allows for multiple structural break effects. To see this, let us start with the following model:

$$\pi_{i,t} = \alpha_i + \sum_{k=1}^{m_i} \theta_{i,k} DU_{i,k,t} + \varepsilon_{i,t} \tag{1}$$

here π represents the inflation rate; subscript $i = 1, \ldots, N$ individual countries and $t = 1, \ldots, T$ time periods; the dummy variable $DU_{i,k,t} = 1$ for $t > T^i_{b,k}$ and 0 elsewhere, where $T^i_{b,k}$ denotes the kth date of the break for the ith individual and $k = 1, \ldots, m_i$, $m_i \geq 1$.[1] Eq. (1) includes: (a) individual structural break effects; that is, shifts in the mean caused by the structural breaks; (b) it allows structural breaks to have different effects on each individual time series, captured by $\theta_{i,k}$; (c) structural breaks are not restricted so they may occur at different locations, that is $T^i_{b,k} \neq T_{b,k}$, $\forall i = \{1, \ldots, N\}$; and (d) individual countries are allowed to have different number of structural breaks $m_i \neq m_j, \forall i \neq j, \{i, j\} = \{1, \ldots, T\}$. Carrion-i-Silvestre et al. (2005) then use the Hadri (2000) procedure, which is constructed using a simple average of the univariate stationarity test in KPSS (1992), to test the null hypothesis of a stationary panel. The test statistic is of the form

$$LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\hat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}_{i,t}^2 \right) \tag{2}$$

where $\hat{S}_{i,t} = \sum_{j=1}^{t} \hat{}_{i,j}$ denotes the partial sum process that is obtained using the estimated OLS residuals from Eq. (1), with $^{2}_{i}$ being a consistent estimate of the long-run variance of $_{i,t}$. Finally, λ denotes the dependence of the test on the dates of the break. For each individual i it is defined as:

$$\lambda_i = \left(\lambda_{i,1}, \ldots, \lambda_{i,m_i}\right)' = \left(T^i_{b,1}/T, \ldots, T^i_{b,m_i}/T\right)' \tag{3}$$

which indicates the relative positions of the dates of the breaks on the entire time period, T. To obtain the location and the number of breaks, Carrion-i-Silvestre et al. (2005) recommend using the Bai and Perron (1998a,b) procedure, which computes the global minimisation of the sum of squared residuals (SSR). The $SSR\left(T^i_{b,1}, \ldots, T^i_{b,m_i}\right)$ is computed from Eq. (1) as follows:

$$\left(\hat{T}^i_{b,1}, \ldots, \hat{T}^i_{b,m_i}\right) = \operatorname{argmin}_{T^i_{b,1}, \ldots, T^i_{b,m_i}} SSR\left(T^i_{b,1}, \ldots, T^i_{b,m_i}\right). \tag{4}$$

Having obtained the dates for all possible $m_i \leq m^{max}$, $i = \{1, \ldots, N\}$, we select the optimal number of breaks for each $i(m_i)$. On the procedure used to estimate the structural breaks, Carrion-i-Silvestre

[1] It is straightforward to follow multiple structural breaks in a univariate series, starting again with Eq. (1) by simply dropping off the subscript i.