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CHARACTERISING THE SOUTH AFRICAN BUSINESS CYCLE: IS GDP DIFFERENCE-STATIONARY OR TREND-STATIONARY IN A MARKOV-SWITCHING SETUP?

ABSTRACT

We test for a unit root in de-trended GDP in a two-state Markov switching specification using a modified Augmented Dickey-Fuller test. Our results show that a first difference GDP specification is preferred over the de-trended specification. In addition, the null of difference-stationary GDP cannot be rejected. By implication, shocks to GDP are permanent which validates specifying trend GDP with a stochastic component – something that is inherently assumed in a number of research papers that estimate potential GDP growth and that model GDP in general equilibrium specifications.

Keywords: Markov-Switching, Difference-Stationary, Trend-Stationary
JEL Classification: C22, C25, E32

RIASSUNTO

Il ciclo economico del Sud Africa: il PIL è stazionario alle differenze o stazionario nel trend in un modello Markov-switching?

In questo studio si effettua un test a radice unitaria sul PIL 'detrendizzato' in un modello Markov-switching a due paesi, utilizzando il test augumented Dickey-Fuller. I risultati mostrano che una specificazione alle differenze prime del PIL è preferibile alla specificazione detrendizzata. Inoltre l'ipotesi nulla di GDP stazionario alle differenze non può essere rigettata. Gli effetti degli shock al PIL risultano permanenti e ciò convalida la specificazione del trend con una componente stocastica – così come assunto in un ampio numero di lavori di ricerca.

1. INTRODUCTION

What characteristics of Gross Domestic Product (GDP) best describe business cycles? Research on whether GDP is trend stationary vs. a stochastic trend has not come full circle – and this has implications for how policy makers think about business cycle properties. A recent discussion in the blog sphere has once again highlighted this issue. Farmer (2015) argues that GDP has a definitive unit root, which implies that shocks have permanent effects; e.g. a negative shock to GDP permanently reduces GDP. Permanent effects on GDP support hysteresis arguments – persistently low growth reduces potential GDP. The implications are far reaching – where government intervention is warranted to correct for deviations in the business cycle or where the economy self-corrects when it deviates from some underlying trend[1], which is inherent in a trend stationary GDP process where shocks are only temporary (Cochrane, 1988).

In terms of dating business cycles, the most common assumption is that log GDP is a random walk with drift where the stationary differences follow an autoregressive Markov Switching (MS) process. Hamilton (1989) imposes a unit root in the trend component where the switching takes place – thus isolating periods of low and high growth. However, Nelson *et al.* (2001) show that standard unit root tests do a poor job in distinguishing trend stationary MS processes from integrated series. Hall *et al.* (1999) overcome this by generalisng the Augmented Dickey and Fuller (1979, ADF) test to allow for MS dynamics. Their results show that GDP is MS trend stationary rather than the trend being stochastic (regime dependent).

The aim of this paper is to test whether the business cycle, captured by GDP, is deterministic or stochastic for South Africa? In the trend-stationary MS case output levels are bounded and fluctuate between two trends that isolate recessions from booms. Cochrane (1988) makes this case – shocks are persistent but not permanent.

Specifically, log GDP is trend stationary if $\sum_{j=0}^{\infty} a_j \varepsilon_{t-j}$ is stationary, i.e. $a_j < 1$ in $y_t = bt + \sum_{j=0}^{\infty} a_j \varepsilon_{t-j}$. Note that t is the trend component. Furthermore if the variance to the random walk component of GDP is zero then the series is trend stationary. In contrast a random walk with drift implies that innovations have permanent effects on GDP and growth rates today imply nothing about future growth.

[1] http://rogerfarmerblog.blogspot.com/2015/04/there-is-no-evidence-that-economy-is.html.

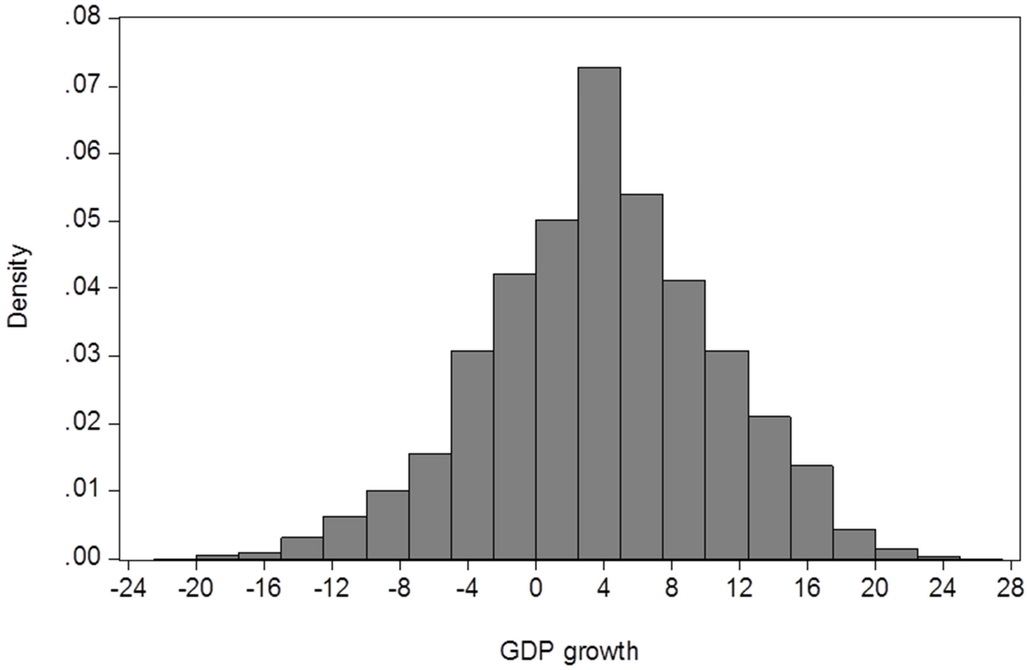
The policy implications when GDP is trend stationary is still uncertain: business cycles that take a long time to self-correct may warrant intervention if it speeds up the correction without adverse repercussions. An ideological debate springs up: are business cycles truly self-correcting absent of any policy intervention? The econometrician's dataset is finite. This data series is an outcome of many economic decisions – some which include government intervention and some which do not. The effects of government intervention on GDP are not purged when testing for a unit root. We are thus unable to confirm the true nature of self-correcting business cycles when standard tests hint at trend stationarity. On the contrary, it is, however, possible that government intervention is too small or too destabilising when GDP contains a unit root.

A MS trend-stationary model implies that there are in fact two trends and GDP moves between those two trends (i.e. it is bounded by an upper and lower level). This simply means that shocks are quite persistent and not permanent. These persistent shocks are often confused for permanent effects – a weakness in many unit root tests.

Potential or trend GDP is explicitly assumed to be stochastic in a number of South African studies. The South African Reserve Bank (SARB) has released two papers recently regarding the modelling assumptions of potential GDP. Both Ehlers *et al.* (2013) and Anvari *et al.* (2014) assume that potential GDP growth has a stochastic component – something that they do not test for. This assumption also means that potential GDP is rather volatile as opposed to being constant. A sufficiently low variance component in the stochastic term (i.e. if the standard deviation is close to zero) would yield a deterministic trend. However, with significant variance one would obtain a large number of potential GDP growth paths – and hence indeterminate equilibria. Figure 1 illustrates a simple Monte Carlo exercise[2]. The first period growth is assumed to be equal to 3.5%. The following periods are a function of past GDP plus noise with zero mean and constant variance. While the mean is close to 3.5% there are large outliers (this is with a variance equal to 1). This simply means that large deviations in potential GDP are possible (assuming that potential GDP growth is stochastic).

[2] We generate 100 series with 100 periods. The first period is initialized to 3.5%. The subsequent periods are a function of a lag plus noise. This illustrates the non-constant potential GDP assumption from the SARB working papers. Specifically, they assume that potential GDP growth is modelled as $\Delta Y_t^T=\Delta Y_{(t-1)}^T+\varepsilon_t$, where ΔY_t^T is potential GDP growth and $\varepsilon_t \sim N(0,\sigma^2)$.

FIGURE 1 - *Simulating Potential GDP Growth with a Stochastic Component*



Regarding business cycle characteristics, the majority of the studies apply Hamilton's (1989) Markov-switching model to date turning points. A core assumption is modelling the growth rate of GDP instead of de-trended GDP. This assumption then pertains to growth cycles only as opposed to business cycles. As mentioned before, shocks to the first difference process of GDP (i.e. GDP growth) has no permanent effect on GDP growth, but may have permanent effects on the level of GDP. Moolman (2007) estimates the data generating processes for GDP growth while controlling for the spread in yields. Moolman (2007) models GDP as an AR(4) process where the switching occurs in the intercept. Du Plessis (2006) uses a non-parametric approach to date turning points. The results have a better fit when de-trending the data as opposed to taking first differences.

Bosch and Ruch (2013) have an interesting approach in dating business cycle turning points. They compress a large data set into the most important components using principle component analysis, to be used in Hamilton's (1989) framework. They use 114 stationary series that make up the formal business cycle dates of the South African Reserve Bank and show that it does a better job at dating turning points than the traditional approach that relies on GDP only.

They compare a specification with only one principle component (explains 15% of the variation in the data) against a specification with eight principle components (explains about 64% of the variation). In both cases they assume that there is no AR component – hence testing only for contemporaneous effects. Their results show that the model with eight principle components does a good job at fitting SARB turning points. The authors, however, mention that their results are based on growth cycles only and hence do not pertain to classic business cycles – something we hope to address in this paper.

2. METHODOLOGY

Our approach is similar to Camacho (2011). First we specify a generalised ADF test that incorporates a MS feature analogous to Hall *et al.* (1999):

$$\Delta y_t = c_{s_t} + \rho y_{t-1} + bt + \sum_{j=1}^{k} \varphi_j \Delta y_{t-j} + \varepsilon_t \quad (1)$$

where y_t is the log of real GDP and the constant is a function of an unobservable state s_t. The state variable evolves according to a two state Markov chain with probabilities defined as:

p(s_t=j|s_(t-1)=s_(t-2)=h,...,Ω_(t-1))=p(s_t=j|s_(t-1)=i)=p_ij,   i,j∈{1,2}

The unit root test is based on a t-statistic (t_p) associated with null of ρ=0 - i.e. GDP contains a unit root. We simulate the model 10000 times under null to compute the associated p-value. The proportion of times the associated t-value is less than the original t-value (t_p) gives the p-value. We evaluate the unit root test using seasonally-adjusted at annual rate GDP data (at constant 2010 prices) from 1960q1 until 2014q4, with the data obtained from the website of the South African Reserve Bank (www.resbank.co.za). Since we analyse the quarter-on-quarter growth rate of real GDP, our effective sample covers the period of 1960q2-2014q4. This period captures changing political regimes and changes to the economic climate – in effect controlling for a number of business cycle phases and possible structural breaks.

3. RESULTS

The results suggest that the MS trend specification is stochastic - i.e. contains a unit root in both regimes (p-value = 0.63940). The first difference stationary model is also preferred to the trend specification[3].

Next we compare the business cycle properties of both the growth rate of GDP and the trend-stationary model against the SARB's cyclical indicator. The estimates are saved under Table 1 with the associated duration of expansions and contractions. The number of lags is determined by the Akaike information criterion.

TABLE 1 - *Comparing the Trend-stationary Specification vs. the Unit Root Specification*

	Unit root model	**Trend-stationary model**
c_1	-0.28 (0.19)	34.14*** (186.15)
c_2	1.19*** (0.12)	35.32*** (460.88)
$\boldsymbol{b}$		0.13*** (12.35)
$\boldsymbol{\rho}$	-0.14* (0.05)	-0.03*** (12171.13)
$\boldsymbol{p_{11}}$	0.82*** (0.07)	0.78*** (9.42)
$\boldsymbol{p_{22}}$	0.95* (0.06)	0.94** (0.01)
Length of expansion	20.31	16.22
Length of contraction	5.54	4.45

Notes: *, **, *** indicate level of significance at the 10%, 5% and 1%, respectively. Standard errors are given in parantheses.

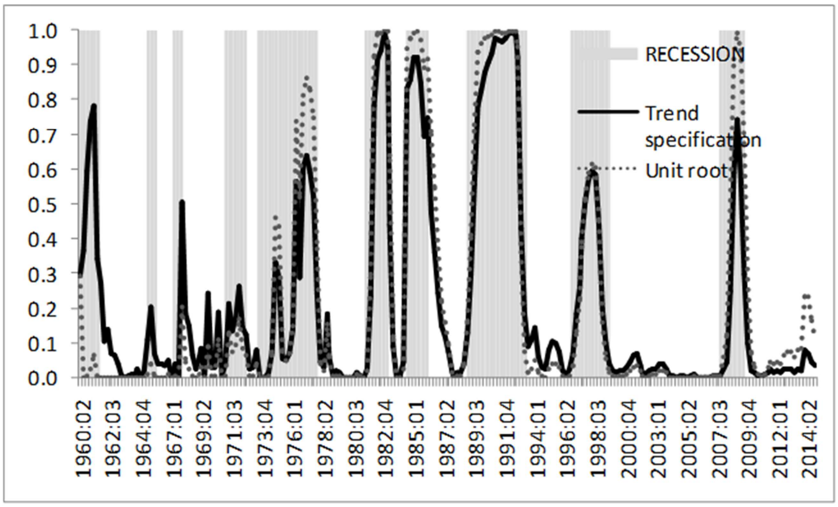
Both expansions and contractions are slightly longer in the unit root specification. Expansions are approximately four quarters longer than in the trend specification and contractions are about 1 quarter longer. Expansions in the unit root specification have a

[3] Not surprisingly, the standard ADF unit root test with a constant and trend in the testing equation, could not reject the null of unit root even at 10 percent level of significance. The test produced a t-statistic of -2.2804 for the logarithms of real GDP, with a p-value of 0.1793.

duration of approximately five years while contractions last slightly less than one and a half year[4] .

Both specifications track the SARB's business cycle indicator equally well. The smoothed probabilities of the contraction regimes are plotted against the SARB's business cycle dates in Figure 2. The unit root and the trend-stationary model are similar in all periods except in 1960.

FIGURE 2 - *Business Cycle Dating*

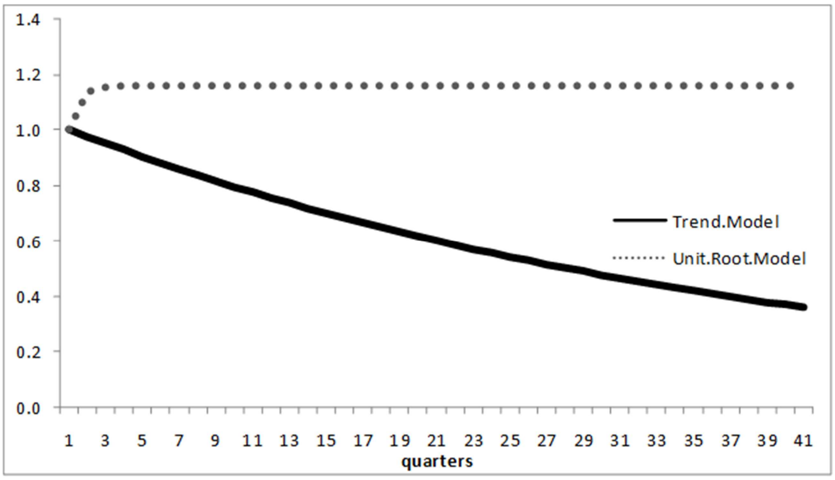


In Figure 3 we compare the impulse responses of the unit root specification to the trend-stationary specification. Linking Figure 3 to the discussion above, shocks to the unit root specification are permanent. In contrast, shocks to the trend-stationary specification are temporary. Admittedly these shocks are persistent – it takes well over 40 quarters for shocks to

[4] For the sake of robustness, we also conducted a quantile unit root test as in Hosseinkouchack and Wolters (2013) using the following equation:
$Q_\tau\,(y_t, y_{t-1}, \ldots, y_{t-q}) = \alpha\,(\tau)\, y_{t-1} + a\,(\tau) + b\,(\tau)\, t + \sum_{j=1}^{k-1} \varphi_j(\tau)\Delta y_{t-j} + \varepsilon_t$. The results have been reported in the Appendix. As can be seen from Table A1, the null of unit root cannot be rejected only at quantiles over 0.20, suggesting that GDP is a difference-stationary process beyond the quantile level of 0.20. Hence, GDP is trend-stationary at the lower tail of the conditional distribution of GDP, with the shocks being less persistent to the extent of being temporary during recessions, something also observed in Figure A1. This result confirms our finding from the MS model that recessions are short-lived than expansions. The reader is referred to Hosseinkouchack and Wolters (2013) for complete details involved in the quantile unit root testing procedure. It is however important to be cautious about the quantile unit root findings, especially, given that we do not allow for the possibility of structural breaks in the testing procedure – a likely issue for an emerging market like South Africa. Note, if a structural break exists, the estimated parameters under the null hypothesis are not close to the true values for at least one subset of the sample (Tillman and Wolters, 2015). Hence, to be completely sure about our results, future research would aim to analyse quantile unit root tests with structural breaks.

truly dissipate. It is possible that this persistence is often confused as a permanent component of GDP, which can readily lead to frequent revisions in estimates such as potential GDP growth. However, our results confirm that the de-trended specification contains a unit root even when imposing two trends. Shocks to GDP are thus not temporary.

FIGURE 3 - *Impulse Responses*



4. CONCLUSION

We test whether South African GDP is trend-stationary in a two regime Markov switching specification. Our results show that both states contain a unit root and that the traditional approach by Hamilton (1989) in characterising business cycles using growth cycles is preferred. We make use of a novel approach that extends the standard ADF test where the null is a function of multiple regimes. South African GDP is not trend-stationary. This has far reaching implications for policy makers.

The explicit assumption that trend GDP is modelled stochastically has now an empirical backing. The non-self-correcting (non-mean-reverting) property of GDP also implies that there is scope for government intervention. We abstract from making specific recommendations being fully aware that some policies have unintended and adverse consequences. However, without adequate policies, negative shocks to the economy might permanently reduce economic growth and hence lead to many revisions in potential GDP and also revisions to policy tools that actively monitor the state of the business cycle such as monetary policy that use Taylor type rules to set interest rates and structural budget calculations that determine the sustainability of fiscal policy.

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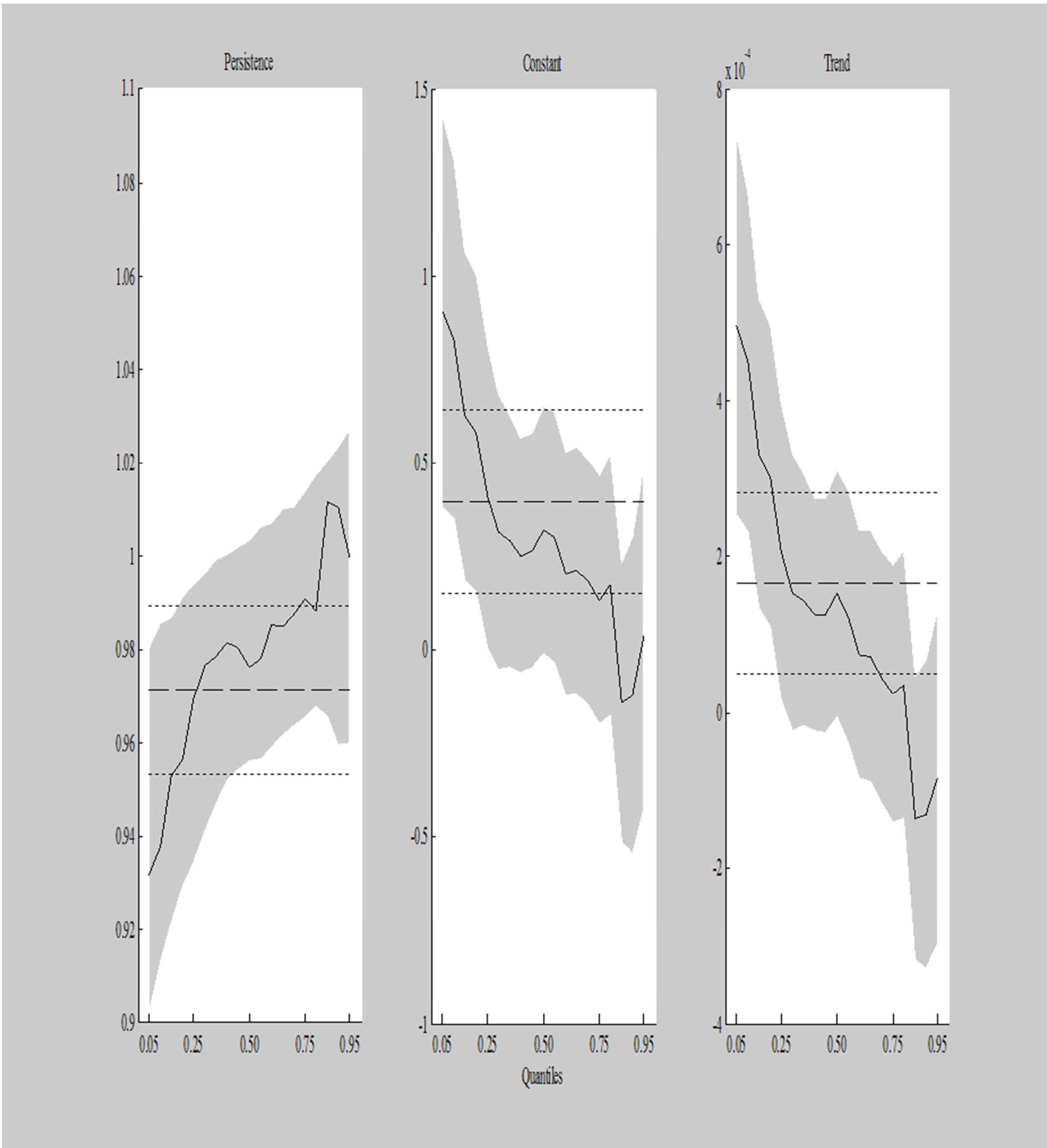
APPENDIX

TABLE A1 - *Quantile Unit Root Test Results*

Quantile	Persistence	t-statistic	Critical Value
0.05	0.9320*	-5.4801	-2.3429
0.10	0.9377*	-4.4942	-2.3155
0.15	0.9530*	-3.0266	-2.8686
0.20	0.9568*	-2.9865	-2.7490
0.25	0.9697	-2.3756	-2.7446
0.30	0.9766	-2.1944	-2.9665
0.35	0.9785	-1.8852	-3.0117
0.40	0.9816	-1.7624	-3.2197
0.45	0.9806	-1.7892	-3.1452
0.50	0.9764	-2.3737	-2.9913
0.55	0.9782	-1.9856	-3.0572
0.60	0.9855	-1.2223	-3.0437
0.65	0.9851	-1.1484	-2.9917
0.70	0.9876	-0.9042	-2.9123
0.75	0.9911	-0.7177	-2.9008
0.80	0.9884	-0.9712	-2.8426
0.85	1.0118	0.7652	-2.7866
0.90	1.0105	0.6832	-2.5494
0.95	0.9995	-0.0395	-2.4758

Notes: the table shows point estimates, t-statistics and critical values for the 5 percent significance level. If the t-statistic is smaller than the critical value then we reject the null hypothesis of persistence $(\alpha(\tau)) = 1$ (see footnote 3 for equation specification) at the 5 percent level. * indicates rejection of the null at 5 percent level of significance.

FIGURE A1 - *Quantile Regression Estimates*



Notes: see Footnote 3 for equation specification.
The graphs show estimates of the persistence parameter $\alpha(\tau)$ and the deterministic parameters $a(\tau)$ and $b(\tau)$ at different quantiles τ = 0.05, 0.1, ..., 0.95. The grey areas indicate 95% bootstrapped confidence bands for the quantile autoregression estimates. The horizontal dashed line shows estimated parameters from a simple mean regression with 95% confidence bands (dotted) for comparison.