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NONLINEAR INFLATIONARY PERSISTENCE AND GROWTH: THEORY AND EMPIRICAL COMPARATIVE ANALYSIS

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Abstract

The paper focuses on the decomposition of inflation persistence into the linear and nonlinear components. The hypothesis is that the nonlinear component of inflation persistence results from a technological shock and might positively contribute to economic growth. The microfoundations are derived from an assumption of Calvo pricing and sticky-information Keynesian Phillips curve. The hypothesis is evaluated empirically with the use of monthly data series for inflation for 119 countries. Linear and nonlinear (bilinear) inflation persistence measures have been estimated with the use of a bilinear autoregressive moving average model in a state space form. Further on, correlation analysis has been performed for these countries to detect a relationship between economic growth and linear and nonlinear persistence. The paper concludes that the nonlinear inflation persistence contributes positively to economic growth after 2000.

Keywords: inflation, growth, bilinear processes
JEL Classification: O50, E31, C22

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1. Introduction

It appears that a long-standing discussion on the relations between inflation and economic growth has recently reached a conclusion. After decades of arguing (for a review of early literature and arguments see e.g. Bruno and Easterley, 1996), the current seems to be that the relation is negative, e.g. high inflation is usually associated with negative growth (see e.g. Barro, 1995, Gillman, Harris and Mátyás, 2002). While not disputing this result, this paper argues that some components of inflation and, in particular, the nonlinear component of non-steady-state inflation persistence, resulting from the dynamic price-setting behaviour, might be positively related to growth.

The subject of dynamic price-setting behaviour and its consequences have substantially gained on popularity within last decade. It has resulted in a stream of papers on the staggered price theory, monetary policy commitments, dynamic policy optimisation, foundation of the new Keynesian Phillips curve, further development of the dynamic stochastic equilibrium models, etc.. In applications of most of these theories, the crucial place is taken by the problem of estimation and interpretation of inflation persistence, understood as the speed in which inflation converges to equilibrium after a shock (e.g. Willis, 2003). Regardless of their groundings, the empirical measures are similar here (for their reviews see e.g. Dias and Marques, 2005, Pivetta and Reis, 2007). Their common feature is the linear nature of the model they developed and hence an impossibility of identification of the linear and nonlinear inflationary persistence.

It is hypothesised in this paper that the source and outcome of nonlinear inflationary persistence is substantially different from the linear one. In particular, the nonlinear component of total persistence is more likely to be related to the economic growth than the linear component. The paper provides a microeconomic reasoning for this assertion and supports it by some empirical findings showing significant correlation of growth with the nonlinear component of inflation persistence.

2. Linear and nonlinear inflation persistence

In the literature (see Granger and Anderson, 1978 and, in economic context, Peel and Davidson, 1998) a process y_t is described as bilinear if it can be expressed as:

$$y_t = \sum_{j=1}^{p} a_j y_{t-j} + \sum_{j=0}^{r} c_j \varepsilon_{t-j} + \sum_{l_1=1}^{m} \sum_{l_2=1}^{k} b_{l_1 l_2} y_{t-l_1} \varepsilon_{t-l_2} ,$$

where: a_j , c_j and $b_{l_1 l_2}$ are parameters and $\{\varepsilon_t\}$ is a sequence of *i.i.d.* random variables with zero expected value, variance σ_ε^2 and finite higher moments.

In a compact notation, the process is denoted as a *BL*(*p*, *r*, *m*, *k*). Here we assume that π_t, that is a deviation of the observed (headline) inflation from its systematic (core) component at time *t*, *t* = 0, 1,…,*T*, is described by a simple symmetric diagonal of the above process:

$$\pi_t = \sum_{j=1}^{p} a_j \pi_{t-j} + \sum_{i=1}^{k} b_i \varepsilon_{t-i} \pi_{t-i} + \varepsilon_t \,, \tag{1}$$

that is, by *BL*(*p*, 1, 0, *k*) with the coefficient c_1=1. The stationarity condition for (1) is complicated and, in a computationally feasible form, can be derived for the case where k = 1 (see Subba Rao, 1981) as:

$$\rho[A \otimes A + B \otimes B\sigma_\varepsilon^2] < 1 \,, \tag{2}$$

where: $\rho[X]$ denotes a maximum absolute value of eigenvalues of matrix *X*, $\otimes$ is a Kronecker product and matrices *A* and *B* are defined as:

$$A = \frac{a}{[I_{p-1}\ 0_{p-1}^{1}]} \quad , \quad B = \frac{b}{0_{p-1}^{p}} \,,$$

where: *a* is 1 × *p* matrix or autoregressive coefficients, *b* is 1 × *p* vector with b_1 being the first element and zeros elsewhere, I_{p-1} is *p*-1 identity matrix and 0_m^n denotes *n* × *m* matrix of nulls.

By analogy with the linear case, where the persistence is measured by the largest (in absolute value) root of the autoregressive polynomial, we regard the left-hand side of (2) as a generalised measure of total persistence. We denote it here as *TP*1.

Among numerous measures of persistence, for a linear case, that is when in (1) all b_i's are equal to zero, we consider here the simplest measure, being the sum of autoregressive coefficients in a linear *AR*(*p*) model. Its straightforward bilinear generalisation is:

$$TP2 = \sum_{j=1}^{p} a_j + \sigma_\varepsilon \sum_{i=1}^{k} |b_i| \,.$$

Both *TP*1 and *TP*2 can be decomposed into the linear and nonlinear parts. In particular, the linear persistence measure in *TP*1, denoted as *LP*1 can be obtained from (2) by setting *B* = 0, and the nonlinear persistence in *TP*1, *NP*1, is obtained from (2) by setting *A* = 0. It should be noticed, however, that *LP*1, based on the eigenvalues of *A*, does not give the same numerical values as the usual measure of persistence in a linear model, based on the eigenvalues of *a*. In stationary models, the largest eigenvalue of *A* is smaller than that of *a*. Analogously, we can derive the linear and nonlinear persistence measures from *TP*2 as:

$$LP2 = \sum_{j=1}^{p} a_j \quad \text{and} \quad NP2 = \sigma_\varepsilon \sum_{i=1}^{k} |b_i| \,.$$

The *TP*1 and *TP*2 measures of persistence are somewhat arbitrary and can be subject of criticisms, as their linear counterparts (see Dias and Marques, 2005, Pivetta and Reis, 2007). In brief, *TP*1 ignores the effects of the eigenvalues other than first, while *TP*2 distorts the general image of persistence if the elements of *TP*2 with small *j*'s are small relatively to these with large *j*'s. This is particularly evident if a_j's are of different signs.

Although similar in interpretation, both types of total persistence measures represent different balance between the linear and nonlinear parts. This is illustrated by Figure 1, which plots *TP*1, *LP*1, *TP*2 and *LP*2 against α_1 in:

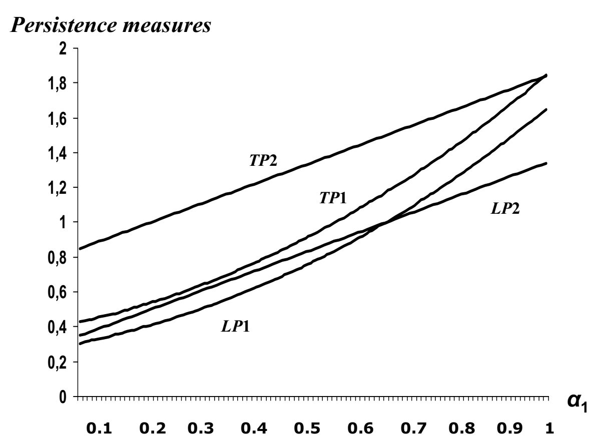
$$\pi_t = \alpha_1 \pi_{t-1} + 0.25\pi_{t-2} + 0.5\varepsilon_{t-1}\pi_{t-1} + \varepsilon_t ,$$

where: ε_t has a unitary variance and $\alpha_1 = 0.1 , 0.11 , \cdots , 1$.

The figure shows that, with the increase of persistence due to a change in α_1, *TP*1 rises faster than *TP*2. For both measures the relations between total and linear persistence are kept constant, which indicates that, as expected, the nonlinear persistence is not changing. Nevertheless, the ratio of linear to nonlinear persistence in *TP*1 is smaller than in *TP*2. When it comes to evaluation of the weight of nonlinear persistence in total, both measures might give different results and hence are not directly comparable.

Figure 1

Persistence measures in a *BL*(2, 1 ,0 ,1) model



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3. Elementary microfoundations

Microfoundations for the applied dynamic scheme which confirm the rationale of assessing the nonlinear persistence with economic growth can be derived as a simple generalization of a variety of staggered-price models. For the sake of argument we have chosen here the Christiano, Eichenbaum and Evans (2005, CEE afterwards) model, due to its widespread popularity, numerous extensions and widespread discussions.

As in most contemporary staggered-price models, it is assumed here that one final consumption good is produced in time *t*, under prefect competition, with the use of a continuum of intermediate goods. Other relevant assumptions are:

(i) In consistence with Calvo (1983) pricing mechanism, firms reoptimise their prices with a constant probability $1-\xi$.

(ii) The resulting price is $\tilde{P}_t$, so that they all choose the same price.

(iii) Those firms which do not reoptimise, set their prices by indexation of their last period price by the inflation rate. This leads to the reformulation of the pricing formula as:

$$P_t = [(1-\xi)(\tilde{P}_t)^{1/(1-\lambda)} + \xi(\frac{P_{t-1}}{P_{t-2}}\tilde{P}_t)^{1/(1-\lambda)}]^{1-\lambda} . \quad (3)$$

where: P_t is the price of the final good and λ is the elasticity of substitution, assumed to be constant.

(iv) The price optimising firms, in their profit maximization problem, are facing the following log-linearised first-order condition:

$$p_t = s_t + E_t\left[\sum_{l=1}^{\infty}(\beta\xi)^l(s_{t+l} - s_{t+l-1}) + \sum_{l=1}^{\infty}(\beta\xi)^l(\pi_{t+l} - \pi_{t+l-1})\right],$$

where: p_t denotes the logarithm of price, s_t is the real marginal cost, β is the discount factor and π_t is the inflation rate.

All time-related variables are expressed in the percentage deviations from the steady-state.

In CEE it is shown that, under certain regularity conditions, (3) leads to the expected inflation equation:

$$\pi_t^e = \pi_{t-1} + \vartheta_t , \quad (4)$$

where: $$\vartheta_t = \frac{(1-\beta\xi)(1-\xi)}{\xi}E_t\sum_{j=0}^{\infty}\beta^j s_{t+j}$$

The term ϑ_t shows the dependence of inflation on expected future real costs adjusted by the Calvo's firms' reoptimising probability. Clearly, the greater ξ is, the smaller is an impact of expected marginal costs on current inflation. It also reduces the inflation persistence. Since the real costs are, in the CEE model, a function of interest rate, real wage and rental cost of capital services, the expected costs must be, analogously, a function of their expectations.

One of the disadvantages of the above specification, which makes the empirical analysis awkward, is the assumption that, unless ϑ_t depends negatively on earlier inflation, in the light of (4), inflation is described by a nonstationary *I*(1) process which, in the light of current findings, is highly disputable (see e.g. Charemza, Hristova and Burridge, 2005, Beechey and Ősterholm, 2009, Halunga, Osborn and Sensier, 2009). In order to relax this problem, it is assumed here that the firms develop an inflationary mean reversion perception, so that a positive deviation of inflation from its steady-state causes the expected real costs to decline. Symmetrically, inflation being below the steady state causes the expected real costs to increase. These changes, however, are not linear. They additionally depend on a monetary shock in time *t*-1 in the sense that a positive shock adjusts negatively the speed of inflationary mean reversion and *vice versa*. We are assuming here that the only cause of the expectations error is a monetary shock g_t, so that $\varepsilon_t = g_t$. With the above assumptions, we can approximate ϑ_t as:

$$\vartheta_t = C_t + \theta_t \pi_{t-1},$$

and $\theta_t = -a + bg_{t-1}$, where *a* and *b* are the parameters and C_t represents a deterministic component of the expected marginal costs. Combining with (4), it gives the following inflation expectations equation:

$$\pi_t^e = C_t + [(1-a) + bg_{t-1}]\pi_{t-1}, \quad (5)$$

which provides the rationale for the empirical bilinear inflation used in this paper. In the light of the CEE model, equation (5) has also an interesting interpretation, which leads to our working hypothesis that nonlinear persistence might affect growth. In particular if, in (5) *a* = *b* = 0, it becomes a linear *I*(1) process. If 0 < *a* < 1 and *b* = 0, it becomes a more realistic *I*(0) process (recall that π_t denotes deviations from the steady state). However, the most interesting case is where $b \neq 0$. In this case a positive monetary shock directly affects expected inflation by either increasing, or decreasing the speed of adjustment, depending on whether *b* > 0 or *b* < 0. Since the probability of firms' reoptimising, $1-\xi$, is usually smaller than one, such temporary change in the speed of adjustment is directly affecting the expected real costs and, as the result, contribute to growth.

The interpretation above differs from alternative explanations of persistence in the CEE model (see Smets and Wouters, 2003, Woodford, 2007). Our proposition is, to some extent, a 'hybrid' one, since it is not possible to identify clearly the consequences of the assumption of invariant and independent Calvo probabilities from other caused of price inertia. In this respect it is closer to the generalisations of Goodfriend and King (1997) and Wolman (1999), developed further by Mash (2004) and Sheedy (2005).

4. Empirical results

For the empirical analysis a panel of monthly time series of annual inflation rates (that is, on the basis of the corresponding month of the previous year) for a wide number of countries has been used. The data are taken from the *International Monetary Fund* database (see http://www.imfstatistics.org/imf). Out of the data set for 182 countries, series for 141 countries have been selected. The series which were incomplete, with a substantial number of missing or systematically repeated observations, have been eliminated. For the remaining series, in a few obvious cases infrequent missing values have been interpolated and some obvious mistakes in data corrected. The data set covers the period from August 1957 to May 2005, but for most countries the series have been shorter. The data length varies from 103 observations for Ireland to 584 for Venezuela. The data are not seasonally adjusted and outliers greater than 5 standard deviations of the series have been truncated (there were very few of them).

The systematic (steady-state) part of inflation has been eliminated by smoothing the data by the Hodrick-Prescott filter with the smoothing constant equal to 16,000. Two versions of equation (1) have been used, with the different lag restriction on the bilinear part. If the lag length for the bilinear part of (1) is restricted to 1, so that $k = 1$, the full set of persistence measures described in Section 2 above, that is *TP*1, *LP*1, *NP*1, *TP*2, *LP*2 and *NP*2 can be used. However, if we allow longer lags for the bilinear part, the persistence measures *TP*1, *LP*1 and *NP*1 cannot be computed. Hence we have decided to set $p = 3$ and $k = 1$, for which all the persistence measures can be computed and, additionally, $p = 3$ and $k = 3$, where we can only compute *TP*2, *LP*2 and *NP*2. For each country the parameters of equation (1) have been estimated by the maximum likelihood method applied to the steady-state representation of (1). While setting $p = 3$ and $k = 1$, the maximum likelihood function converged to a maximum for 140 countries and, for $p = 3$ and $k = 1$, for 133 countries. In the remaining cases the computations failed.

Appendix A contains the evaluations of the persistence measures for individual countries. In Table A1 the measures for $p = 3$ and $k = 1$ are given and Table A2 contains the results for $p = 3$ and $k = 3$ and also the differences between *TP*2, *LP*2 and *NP*2 obtained for $k = 1$ and $k = 3$. These differences give an idea of a possible bias of all measures due to the misspecification of the lag length in the bilinear term of the model. These differences are for most cases positive (especially for the total linear persistence measures), suggesting possible downward bias of the appropriate measures computed for $p = 3$ and $k = 1$.

Since, according to most sources, the year 2000 constituted a threshold in the world development, it has been decided, following the World Bank Convention, to apply the average rate of growth computed for the period 1990-2000 and, separately, for 2000-2005. For countries for which a data match was possible (that is, where there were both growth data available and convergence of the maximum likelihood estimates was achieved), simple correlation was computed between the average GDP and total, linear and nonlinear persistence. There are 120 such countries for the estimates obtained for $p = 3$ and $k = 1$ and 113 for $p = 3$ and $k = 3$.

Table 1

Correlation coefficients for average growth and persistence measures

	Average rate of *GDP* growth		
	1990-2000	2000-2004	1990-2004
	$p = 3$, $k = 1$		
*TP*1	-0.166	0.276	-0.047
*LP*1	-0.168	0.258	-0.0562
*NP*1	-0.076	0.258	-0.056
*TP*2	-0.092	0.312	0.043

	Average rate of *GDP* growth		
	1990-2000	2000-2004	1990-2004
	p = 3 , *k* = 1		
*LP*2	-0.077	0.212	0.015
*NP*2	-0.0749	0.390	0.0927
	p = 3 , *k* = 3		
*TP*2	-0.046	0.253	0.064
*LP*2	0.003	0.124	0.057
*NP*2	-0.136	0.384	0.029

The results given in Table 1 show no signs of correlation between growth and persistence of any kind, where the growth rate is averaged for 1990-2004 and also for 1990-2000. There are even some indications of a negative relationship for this period. However, for the years 2000-2004 the picture is different. All the persistence measures computed are markedly and positively correlated with average growth. In particular, it is evident that nonlinear persistence correlates with growth much stronger than the linear one.

5. Concluding remarks

The paper presents a relatively simple method of assessing the maximal admissible forecast horizon for non-systematic inflation. The empirical results indicate the plausibility of the method which might be implemented in practice by monetary policy authorities and forecasting institutions. It can also be used as an auxiliary tool for evaluation of the rationale of inflation smoothing. However, the bilinear model used here is relatively simple and its extension (for instance, by allowing for more complicated lags structure) is likely to increase its efficiency.

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Appendix A

Table A1

Persistence measures, *p* = 3 , *k* = 1

Country	No.obs	*TP*1	*LP*1	*NP*1	*TP*2	*LP*2	*NP*2
ALBA	161	0.4297	0.4289	0.0002	0.8061	0.7932	0.0129
ALGE	352	0.3962	0.3962	0.0000	0.6369	0.6308	0.0061
ANGO	164	0.5080	0.4994	0.0007	0.9088	0.8827	0.0261
ARGE	573	0.3683	0.3589	0.0002	0.8851	0.8719	0.0132
ARME	141	1.2080	1.1420	0.0405	1.2522	1.0510	0.2012
ARUB	236	0.5009	0.5009	0.0000	0.8044	0.8008	0.0036
AUST	571	0.2431	0.2378	0.0020	0.6556	0.6104	0.0452
AZER	160	0.7525	0.7437	0.0045	0.9632	0.8964	0.0667
BAHA	397	0.6217	0.6210	0.0006	0.8143	0.7892	0.0251
BAHR	306	0.4303	0.4303	0.0000	0.5873	0.5873	0.0000
BARB	461	0.3309	0.3306	0.0000	0.7268	0.7206	0.0063
BELA	152	0.6091	0.5882	0.0017	0.9551	0.9138	0.0413
BELG	573	0.4325	0.4324	0.0000	0.7508	0.7471	0.0036
BENI	145	0.4300	0.4299	0.0001	0.7311	0.7222	0.0089
BOLI	571	0.7821	0.7821	0.0000	0.9075	0.9039	0.0036
BOTS	362	0.4087	0.2989	0.0102	0.8536	0.7525	0.1010
BRAZ	297	0.7467	0.7467	0.0000	0.9277	0.9258	0.0020
BULG	165	0.7368	0.7367	0.0001	0.8750	0.8646	0.0104
BURK	539	0.4888	0.4887	0.0001	0.7054	0.6972	0.0081
BURU	378	0.4631	0.4628	0.0003	0.7007	0.6841	0.0166
CAMB	119	0.4458	0.4457	0.0001	0.6867	0.6752	0.0115
CAME	403	0.5477	0.5420	0.0028	0.8433	0.7904	0.0529
CANA	571	0.3793	0.3784	0.0001	0.7650	0.7555	0.0095
CAPE	163	0.3238	0.3178	0.0015	0.7124	0.6737	0.0387
CENT	279	0.6247	0.6247	0.0000	0.8013	0.7976	0.0037
CHAD	241	0.5766	0.5747	0.0010	0.8377	0.8057	0.0320
CHIL	573	0.5473	0.5471	0.0002	0.7777	0.7649	0.0128
CHIN	220	0.6044	0.6036	0.0002	0.8787	0.8643	0.0144
CHHK	286	0.6103	0.6100	0.0006	0.7519	0.7267	0.0252
COLO	573	0.5703	0.5703	0.0000	0.8800	0.8799	0.0002
CONG	495	0.4785	0.4780	0.0001	0.8604	0.8524	0.0080
COST	370	0.7013	0.7012	0.0000	0.8861	0.8797	0.0063
COTE	528	0.5015	0.5013	0.0002	0.6779	0.6638	0.0141
CROA	225	0.6332	0.6284	0.0048	0.8614	0.7923	0.0691
CYPR	568	0.3809	0.3808	0.0001	0.6792	0.6713	0.0079
CZEC	138	0.5087	0.5085	0.0001	0.8489	0.8414	0.0075
DENM	452	0.4907	0.4907	0.0000	0.7667	0.7662	0.0004
DOMI	467	0.5556	0.5549	0.0014	0.7182	0.6813	0.0370
DOMR	572	0.4780	0.4598	0.0010	0.8778	0.8461	0.0316
EQUA	573	0.4840	0.4822	0.0004	0.8484	0.8295	0.0188
EGYP	572	0.2923	0.2887	0.0016	0.6848	0.6446	0.0402
ELSA	570	0.6785	0.6762	0.0028	0.8619	0.8093	0.0526
ESTO	152	0.8719	0.8588	0.0153	1.0460	0.9222	0.1238
ETHI	445	0.5675	0.5667	0.0004	0.8134	0.7927	0.0208
FIJI	426	0.4792	0.4791	0.0000	0.7641	0.7579	0.0061

Country	No.obs	*TP*1	*LP*1	*NP*1	*TP*2	*LP*2	*NP*2
FINL	573	0.5365	0.5364	0.0000	0.7831	0.7787	0.0044
FRAN	573	0.5833	0.5782	0.0021	0.8683	0.8224	0.0460
GABO	169	0.3855	0.3646	0.0016	0.8376	0.7972	0.0404
GEOR	123	0.6375	0.6375	0.0000	0.7231	0.7190	0.0041
GERM	164	0.3301	0.3294	0.0006	0.6221	0.5969	0.0252
GHAN	493	0.5975	0.5973	0.0001	0.8571	0.8484	0.0087
GREE	573	0.3435	0.3435	0.0000	0.7694	0.7677	0.0017
GREN	311	0.5563	0.5561	0.0002	0.7257	0.7103	0.0154
GUAT	569	0.6006	0.6006	0.0000	0.7804	0.7792	0.0012
GUIN	215	0.6608	0.6599	0.0016	0.8080	0.7683	0.0397
GUYA	126	0.4232	0.4223	0.0016	0.6503	0.6105	0.0398
HAIT	569	0.4887	0.4887	0.0000	0.7121	0.7061	0.0060
HOND	572	0.6372	0.6372	0.0000	0.8238	0.8184	0.0054
HUNG	345	0.4609	0.4609	0.0000	0.7662	0.7657	0.0005
ICEL	261	0.5665	0.5628	0.0007	0.8957	0.8689	0.0268
INDI	566	0.7027	0.7027	0.0000	0.8805	0.8762	0.0043
INDO	441	0.7814	0.7744	0.0038	0.9704	0.9086	0.0618
IRAN	533	0.5473	0.5468	0.0001	0.8367	0.8257	0.0111
IREL	102	0.7787	0.7225	0.0163	1.0408	0.9131	0.1276
ISRA	569	0.7022	0.7018	0.0001	0.9077	0.8955	0.0122
ITAL	572	0.6101	0.6101	0.0000	0.8679	0.8667	0.0012
JAMA	569	0.5846	0.5846	0.0000	0.8911	0.8905	0.0005
JAPA	561	0.4966	0.4965	0.0001	0.7689	0.7605	0.0084
JORD	341	0.4741	0.4736	0.0004	0.7301	0.7106	0.0196
KAZA	140	0.7750	0.7728	0.0006	0.9024	0.8785	0.0239
KENY	451	0.4338	0.4336	0.0000	0.8165	0.8110	0.0055
KORE	428	0.4874	0.4864	0.0003	0.8316	0.8145	0.0171
KYRG	115	0.5214	0.4906	0.0021	0.9031	0.8568	0.0464
LAOP	184	0.5451	0.5388	0.0016	0.8843	0.8449	0.0394
LATV	164	0.6620	0.6613	0.0009	0.8181	0.7883	0.0298
LITH	152	0.7475	0.7461	0.0020	0.8866	0.8420	0.0446
LUXE	571	0.3200	0.3186	0.0003	0.6967	0.6800	0.0167
MACE	133	0.3700	0.3588	0.0002	0.7774	0.7624	0.0150
MADA	487	0.7132	0.7131	0.0001	0.8537	0.8444	0.0093
MALA	295	0.6652	0.6651	0.0001	0.8455	0.8371	0.0084
MALY	566	0.6429	0.6429	0.0000	0.8293	0.8228	0.0065
MALI	192	0.3351	0.3128	0.0022	0.7774	0.7305	0.0469
MALT	564	0.5600	0.5596	0.0006	0.7149	0.6901	0.0248
MAUT	225	0.5031	0.5030	0.0001	0.7067	0.6952	0.0114
MAUR	504	0.4712	0.4687	0.0005	0.8299	0.8085	0.0213
MEXI	572	0.6550	0.6444	0.0011	0.9541	0.9216	0.0325
MOLD	113	0.8260	0.8255	0.0022	0.8671	0.8201	0.0470
MONG	152	0.6497	0.6468	0.0077	0.8036	0.7158	0.0879
MORO	570	0.3244	0.3238	0.0001	0.7365	0.7278	0.0086
MOZA	141	0.4661	0.4452	0.0111	0.8433	0.7382	0.1052
MAYN	420	0.4282	0.4222	0.0015	0.7999	0.7607	0.0392
NANI	168	0.6047	0.6039	0.0003	0.8422	0.8240	0.0182
NEPA	490	0.6685	0.6685	0.0000	0.8190	0.8176	0.0014
NETH	570	0.4651	0.4651	0.0000	0.7028	0.7006	0.0022
NETA	443	0.6983	0.6971	0.0010	0.8845	0.8536	0.0310

Country	No.obs	*TP*1	*LP*1	*NP*1	*TP*2	*LP*2	*NP*2
NICA	356	0.5939	0.5932	0.0001	0.9008	0.8901	0.0106
NIGE	432	0.3398	0.3375	0.0010	0.6886	0.6577	0.0309
NIGR	533	0.6119	0.6117	0.0001	0.8489	0.8387	0.0102
NORW	578	0.6192	0.6186	0.0004	0.8376	0.8169	0.0207
PAKI	567	0.3979	0.3979	0.0000	0.7850	0.7846	0.0004
PANA	356	0.5313	0.5304	0.0011	0.7426	0.7091	0.0335
PARA	572	0.3601	0.3594	0.0002	0.7384	0.7259	0.0124
PERU	572	0.5265	0.5264	0.0000	0.8292	0.8251	0.0041
PHIL	570	0.5415	0.5415	0.0000	0.8019	0.7994	0.0025
POLA	200	0.6855	0.6855	0.0000	0.9086	0.9079	0.0008
PORT	572	0.5010	0.5000	0.0005	0.7854	0.7626	0.0228
ROMA	168	0.5480	0.5447	0.0002	0.8896	0.8745	0.0152
RUSS	151	0.4847	0.4826	0.0002	0.8887	0.8752	0.0135
SAMO	450	0.6563	0.6562	0.0000	0.8194	0.8138	0.0056
SAUD	291	0.4397	0.4374	0.0006	0.7679	0.7428	0.0251
SENE	443	0.3474	0.3467	0.0002	0.7434	0.7307	0.0127
SEYC	417	0.4912	0.4908	0.0005	0.6922	0.6691	0.0230
SIER	226	0.4522	0.4513	0.0005	0.7385	0.7153	0.0232
SING	516	0.7084	0.7084	0.0000	0.8427	0.8387	0.0040
SLOVA	140	0.4413	0.4412	0.0000	0.7782	0.7739	0.0043
SLOVE	153	0.9451	0.9416	0.0081	1.0459	0.9559	0.0900
SOLO	312	0.5754	0.5754	0.0000	0.7532	0.7525	0.0007
SOUT	572	0.3684	0.3546	0.0007	0.8000	0.7734	0.0266
SPAI	574	0.3886	0.3847	0.0009	0.8045	0.7737	0.0308
SRIL	568	0.3065	0.3065	0.0000	0.7290	0.7270	0.0020
STKI	242	0.3196	0.3166	0.0005	0.6955	0.6739	0.0216
STLU	463	0.6287	0.6278	0.0009	0.8285	0.7993	0.0293
STVI	320	0.1992	0.1990	0.0001	0.5675	0.5569	0.0106
SURI	426	0.6050	0.6048	0.0000	0.8840	0.8774	0.0066
SWAZ	452	0.3446	0.3446	0.0000	0.5884	0.5870	0.0014
SWED	572	0.4590	0.4582	0.0003	0.7704	0.7543	0.0161
SWIT	567	0.3980	0.3978	0.0001	0.7678	0.7596	0.0082
THAI	474	0.6128	0.6113	0.0004	0.8750	0.8543	0.0207
TONG	187	0.3701	0.3637	0.0047	0.7184	0.6499	0.0685
TRIN	569	0.5770	0.5768	0.0001	0.7796	0.7685	0.0111
TUNIS	207	0.5976	0.5963	0.0006	0.8488	0.8243	0.0245
TURK	429	0.4762	0.4760	0.0001	0.8277	0.8206	0.0072
UGAN	283	0.5275	0.5231	0.0025	0.7910	0.7409	0.0501
UKRA	151	0.6438	0.6438	0.0000	0.8585	0.8568	0.0017
UNITK	566	0.6486	0.6484	0.0001	0.8616	0.8519	0.0097
UNITS	573	0.3627	0.3623	0.0001	0.7945	0.7874	0.0071
URUG	573	0.6231	0.6229	0.0001	0.8545	0.8430	0.0115
VENE	583	0.6207	0.6206	0.0000	0.8468	0.8417	0.0051
VIET	114	0.6486	0.6476	0.0003	0.8966	0.8785	0.0180
ZAMBI	235	0.5645	0.5586	0.0016	0.8846	0.8447	0.0399
ZIMB	278	0.5231	0.5231	0.0000	0.7824	0.7804	0.0020

Table A2

Persistence measures, *p* = 3 , *k* = 3

Country	No.obs	*TP*2	*LP*2	*NP*2	dif*TP*2	dif*LP*2	dif*NP*2
ALBA	161	0.8366	0.8186	0.0180	0.0305	0.0254	0.0051
ALGE	352	0.7241	0.7186	0.0055	0.0872	0.0878	-0.0006
ANGO	164	0.9593	0.9255	0.0338	0.0505	0.0428	0.0077
ARGE	573	0.9233	0.9080	0.0153	0.0382	0.0361	0.0021
ARME	141	1.1357	0.9397	0.1960	-0.1165	-0.1113	-0.0052
ARUB	236	0.8589	0.8344	0.0245	0.0545	0.0336	0.0209
AUST	571	0.7200	0.6719	0.0481	0.0644	0.0615	0.0029
AZER	160	0.9911	0.9270	0.0640	0.0279	0.0306	-0.0027
BAHA	397	0.8135	0.7860	0.0276	-0.0008	-0.0032	0.0025
BAHR	306	0.5468	0.5452	0.0016	-0.0405	-0.0421	0.0016
BARB	461	0.7434	0.7376	0.0058	0.0166	0.0170	-0.0005
BELA	152	0.9497	0.9406	0.0091	-0.0054	0.0268	-0.0322
BELG	573	0.7805	0.7772	0.0033	0.0297	0.0301	-0.0003
BENI	145	0.7953	0.7922	0.0031	0.0642	0.0700	-0.0058
BOLI	571	0.9120	0.9057	0.0063	0.0045	0.0018	0.0027
BOTS	362	0.9121	0.8058	0.1063	0.0585	0.0533	0.0053
BRAZ	297	0.9701	0.9551	0.0150	0.0424	0.0293	0.0130
BULG	165	0.8900	0.8812	0.0088	0.0150	0.0166	-0.0016
BURK	539	0.6854	0.6798	0.0055	-0.0200	-0.0174	-0.0026
BURU	378	0.6980	0.6810	0.0170	-0.0027	-0.0031	0.0004
CAMB	119	0.7079	0.6974	0.0105	0.0212	0.0222	-0.0010
CAME	403	0.8740	0.8180	0.0560	0.0307	0.0276	0.0031
CANA	571	0.8076	0.7967	0.0109	0.0426	0.0412	0.0014
CAPE	163	0.7413	0.7084	0.0330	0.0289	0.0347	-0.0057
CENT	279	0.8029	0.7980	0.0049	0.0016	0.0004	0.0012
CHAD	241	0.8532	0.8323	0.0209	0.0155	0.0266	-0.0111
CHIL	573	0.7860	0.7753	0.0107	0.0083	0.0104	-0.0021
CHIN	220	0.9380	0.9157	0.0224	0.0593	0.0514	0.0080
CHHK	286	0.7134	0.6898	0.0237	-0.0385	-0.0369	-0.0015
COLO	573	0.9178	0.9123	0.0056	0.0378	0.0324	0.0054
CONG	495	0.9095	0.8977	0.0117	0.0491	0.0453	0.0037
COST	370	0.9071	0.9043	0.0028	0.0210	0.0246	-0.0035
COTE	528	0.6552	0.6521	0.0031	-0.0227	-0.0117	-0.0110
CROA	225	0.8604	0.7903	0.0701	-0.0010	-0.0020	0.0010
CYPR	568	0.7002	0.6905	0.0096	0.0210	0.0192	0.0017
CZEC	138	0.8988	0.8893	0.0095	0.0499	0.0479	0.0020
DENM	452	0.8023	0.7954	0.0068	0.0356	0.0292	0.0064
DOMI	467	0.6776	0.6404	0.0373	-0.0406	-0.0409	0.0003
DOMR	572	0.9078	0.8855	0.0223	0.0300	0.0394	-0.0093
EQUA	573	0.8908	0.8757	0.0151	0.0424	0.0462	-0.0037
EGYP	572	0.7088	0.6699	0.0389	0.0240	0.0253	-0.0013
ELSA	570	0.8020	0.7837	0.0183	-0.0599	-0.0256	-0.0343
ESTO	152	0.9079	0.7876	0.1204	-0.1381	-0.1346	-0.0034
ETHI	445	0.8339	0.8128	0.0210	0.0205	0.0201	0.0002
FIJI	426	0.7900	0.7810	0.0090	0.0259	0.0231	0.0029
FRAN	573	0.9238	0.8791	0.0446	0.0555	0.0567	-0.0014
GABO	169	0.8870	0.8445	0.0425	0.0494	0.0473	0.0021

Country	No.obs	*TP*2	*LP*2	*NP*2	dif*TP*2	dif*LP*2	dif*NP*2
GEOR	123	0.7470	0.7375	0.0095	0.0239	0.0185	0.0054
GERM	164	0.6979	0.6725	0.0254	0.0758	0.0756	0.0002
GHAN	493	0.9116	0.9048	0.0068	0.0545	0.0564	-0.0019
GREE	573	0.8123	0.8100	0.0023	0.0429	0.0423	0.0006
GREN	311	0.7058	0.6915	0.0143	-0.0199	-0.0188	-0.0011
GUAT	569	0.7832	0.7825	0.0007	0.0028	0.0033	-0.0005
GUIN	215	0.7770	0.7342	0.0427	-0.0310	-0.0341	0.0030
GUYA	126	0.6691	0.6290	0.0401	0.0188	0.0185	0.0003
HOND	572	0.8361	0.8316	0.0045	0.0123	0.0132	-0.0009
ICEL	261	0.8876	0.8687	0.0189	-0.0081	-0.0002	-0.0079
INDI	566	0.9017	0.8959	0.0058	0.0212	0.0197	0.0015
INDO	441	0.9787	0.9228	0.0559	0.0083	0.0142	-0.0059
IRAN	533	0.8621	0.8581	0.0040	0.0254	0.0324	-0.0071
IREL	102	1.0410	0.9303	0.1106	0.0002	0.0172	-0.0170
ISRA	569	0.9152	0.9125	0.0027	0.0075	0.0170	-0.0095
ITAL	572	0.9014	0.8975	0.0039	0.0335	0.0308	0.0027
JAMA	569	0.9243	0.9224	0.0020	0.0332	0.0319	0.0015
JAPA	561	0.7901	0.7864	0.0037	0.0212	0.0259	-0.0047
JORD	341	0.7552	0.7275	0.0276	0.0251	0.0169	0.0080
KAZA	140	0.9483	0.9161	0.0323	0.0459	0.0376	0.0084
KENY	451	0.8551	0.8492	0.0059	0.0386	0.0382	0.0004
KORE	428	0.8862	0.8760	0.0102	0.0546	0.0615	-0.0069
KYRG	115	0.9269	0.8982	0.0287	0.0238	0.0414	-0.0177
LAOP	184	0.9068	0.8739	0.0329	0.0225	0.0290	-0.0065
LATV	164	0.8294	0.7836	0.0459	0.0113	-0.0047	0.0161
LITH	152	0.8773	0.8570	0.0203	-0.0093	0.0150	-0.0243
LUXE	571	0.7323	0.7171	0.0152	0.0356	0.0371	-0.0015
MACE	133	0.8189	0.7970	0.0219	0.0415	0.0346	0.0069
MADA	487	0.8537	0.8444	0.0093	0.0000	0.0000	0.0000
MALA	295	0.8541	0.8494	0.0047	0.0086	0.0123	-0.0037
MALY	566	0.8445	0.8365	0.0080	0.0152	0.0137	0.0015
MALI	192	0.8149	0.7614	0.0536	0.0375	0.0309	0.0067
MALT	564	0.6914	0.6648	0.0266	-0.0235	-0.0253	0.0018
MAUT	225	0.6573	0.6439	0.0134	-0.0494	-0.0513	0.0020
MAUR	504	0.8749	0.8494	0.0254	0.0450	0.0409	0.0041
MEXI	572	0.9413	0.9375	0.0039	-0.0128	0.0159	-0.0286
MOLD	113	0.6783	0.6121	0.0662	-0.1888	-0.2080	0.0192
MONG	152	0.7789	0.6960	0.0829	-0.0247	-0.0198	-0.0050
MORO	570	0.7802	0.7750	0.0052	0.0437	0.0472	-0.0034
MOZA	141	0.8814	0.7921	0.0893	0.0381	0.0539	-0.0159
MAYN	420	0.8422	0.8027	0.0395	0.0423	0.0420	0.0003
NANI	168	0.8509	0.842	0.0089	0.0087	0.0180	-0.0093
NEPA	490	0.819	0.8176	0.0014	0.0000	0.0000	0.0000
NETH	570	0.7143	0.7127	0.0016	0.0115	0.0121	-0.0006
NETA	443	0.9063	0.8678	0.0385	0.0218	0.0142	0.0075
NICA	356	0.9326	0.9294	0.0032	0.0318	0.0393	-0.0074
NIGE	432	0.7179	0.6916	0.0263	0.0293	0.0339	-0.0046
NIGR	533	0.8680	0.8630	0.0050	0.0191	0.0243	-0.0052
NORW	578	0.8510	0.8341	0.0169	0.0134	0.0172	-0.0038
PAKI	567	0.8383	0.8311	0.0072	0.0533	0.0465	0.0068

Country	No.obs	*TP*2	*LP*2	*NP*2	dif*TP*2	dif*LP*2	dif*NP*2
PANA	356	0.7443	0.7100	0.0343	0.0017	0.0009	0.0008
PARA	572	0.7720	0.7689	0.0031	0.0336	0.0430	-0.0093
PERU	572	0.8849	0.8831	0.0018	0.0557	0.0580	-0.0023
PHIL	570	0.8277	0.8252	0.0025	0.0258	0.0258	0.0000
POLA	200	0.9452	0.9358	0.0094	0.0366	0.0279	0.0086
PORT	572	0.8084	0.7893	0.0191	0.0230	0.0267	-0.0037
ROMA	168	0.9427	0.9090	0.0337	0.0531	0.0345	0.0185
RUSS	151	0.9471	0.9148	0.0323	0.0584	0.0396	0.0188
SAMO	450	0.8304	0.8197	0.0107	0.0110	0.0059	0.0051
SAUD	291	0.7817	0.7646	0.0171	0.0138	0.0218	-0.0080
SENE	443	0.7740	0.7631	0.0108	0.0306	0.0324	-0.0019
SEYC	417	0.6738	0.6479	0.0259	-0.0184	-0.0212	0.0029
SIER	226	0.7784	0.7509	0.0275	0.0399	0.0356	0.0043
SING	516	0.8370	0.8346	0.0024	-0.0057	-0.0041	-0.0016
SLOVA	140	0.8387	0.8126	0.0261	0.0605	0.0387	0.0218
SLOVE	153	0.9632	0.8024	0.1608	-0.0827	-0.1535	0.0708
SOUT	572	0.8346	0.8091	0.0255	0.0346	0.0357	-0.0011
SPAI	574	0.8536	0.8257	0.0279	0.0491	0.0520	-0.0029
SRIL	568	0.7737	0.7723	0.0015	0.0447	0.0453	-0.0005
STKI	242	0.7712	0.7236	0.0476	0.0757	0.0497	0.0260
STLU	463	0.8343	0.8050	0.0293	0.0058	0.0057	0.0000
STVI	320	0.5976	0.5890	0.0087	0.0301	0.0321	-0.0019
SURI	426	0.9113	0.9068	0.0045	0.0273	0.0294	-0.0021
SWAZ	452	0.5884	0.5870	0.0014	0.0000	0.0000	0.0000
SWED	572	0.8018	0.7854	0.0164	0.0314	0.0311	0.0003
THAI	474	0.9019	0.8835	0.0184	0.0269	0.0292	-0.0023
TONG	187	0.7715	0.7167	0.0548	0.0531	0.0668	-0.0137
TRIN	569	0.7852	0.7748	0.0104	0.0056	0.0063	-0.0007
TUNIS	207	0.8837	0.8535	0.0302	0.0349	0.0292	0.0057
UGAN	283	0.8701	0.8279	0.0422	0.0791	0.0870	-0.0079
UKRA	151	0.9118	0.8941	0.0177	0.0533	0.0373	0.0160
UNITK	566	0.8833	0.8761	0.0072	0.0217	0.0242	-0.0025
UNITS	573	0.8467	0.8400	0.0067	0.0522	0.0526	-0.0004
URUG	573	0.8758	0.8680	0.0078	0.0213	0.0250	-0.0037
VENE	583	0.9121	0.9045	0.0076	0.0653	0.0628	0.0025
ZAMBI	235	0.9362	0.9019	0.0343	0.0516	0.0572	-0.0056
ZIMB	278	0.8133	0.8088	0.0045	0.0309	0.0284	0.0025

List of country names and codes

Country name	code
ALBANIA	ALBA
ALGERIA	ALGE
ANGOLA	ANGO
ARGENTINA	ARGE
ARMENIA	ARME
ARUBA	ARUB

Country name	code
AUSTRIA	AUST
AZERBAIJAN. REP. OF	AZER
BAHAMAS. THE	BAHA
BAHRAIN. KINGDOM OF	BAHR
BARBADOS	BARB
BELARUS	BELA
BELGIUM	BELG
BENIN	BENI
BOLIVIA	BOLI
BOTSWANA	BOTS
BRAZIL	BRAZ
BULGARIA	BULG
BURKINA FASO	BURK
BURUNDI	BURU
CAMBODIA	CAMB
CAMEROON	CAME
CANADA	CANA
CAPE VERDE	CAPE
CENTRAL AFRICAN REP.	CENT
CHAD	CHAD
CHILE	CHIL
CHINA.P.R.: MAINLAND	CHIN
CHINA.P.R.:HONG KONG	CHHK
COLOMBIA	COLO
CONGO. DEM. REP. OF	CONG
COSTA RICA	COST
COTE D IVOIRE	COTE
CROATIA	CROA
CYPRUS	CYPR
CZECH REPUBLIC	CZEC
DENMARK	DENM
DOMINICA	DOMI
DOMINICAN REPUBLIC	DOMR
ECUADOR	EQUA
EGYPT	EGYP
EL SALVADOR	ELSA
ESTONIA	ESTO
ETHIOPIA	ETHI
FIJI	FIJI
FINLAND	FINL
FRANCE	FRAN
GABON	GABO
GEORGIA	GEOR
GERMANY	GERM
GHANA	GHAN

Country name	code
GREECE	GREE
GRENADA	GREN
GUATEMALA	GUAT
GUINEA-BISSAU	GUIN
GUYANA	GUYA
HAITI	HAIT
HONDURAS	HOND
HUNGARY	HUNG
ICELAND	ICEL
INDIA	INDI
INDONESIA	INDO
IRAN. I.R. OF	IRAN
IRELAND	IREL
ISRAEL	ISRA
ITALY	ITAL
JAMAICA	JAMA
JAPAN	JAPA
JORDAN	JORD
KAZAKHSTAN	KAZA
KENYA	KENY
KOREA	KORE
KYRGYZ REPUBLIC	KYRG
LAO PEOPLE S DEM.REP	LAOP
LATVIA	LATV
LITHUANIA	LITH
LUXEMBOURG	LUXE
MACEDONIA. FYR	MACE
MADAGASCAR	MADA
MALAWI	MALA
MALAYSIA	MALY
MALI	MALI
MALTA	MALT
MAURITANIA	MAUT
MAURITIUS	MAUR
MEXICO	MEXI
MOLDOVA	MOLD
MONGOLIA	MONG
MOROCCO	MORO
MOZAMBIQUE	MOZA
MYANMAR	MAYN
NAMIBIA	NANI
NEPAL	NEPA
NETHERLANDS	NETH
NETHERLANDS ANTILLES	NETA
NICARAGUA	NICA

Country name	code
NIGER	NIGE
NIGERIA	NIGR
NORWAY	NORW
PAKISTAN	PAKI
PANAMA	PANA
PARAGUAY	PARA
PERU	PERU
PHILIPPINES	PHIL
POLAND	POLA
PORTUGAL	PORT
ROMANIA	ROMA
RUSSIA	RUSS
SAMOA	SAMO
SAUDI ARABIA	SAUD
SENEGAL	SENE
SEYCHELLES	SEYC
SIERRA LEONE	SIER
SINGAPORE	SING
SLOVAK REPUBLIC	SLOA
SLOVENIA	SLOE
SOLOMON ISLANDS	SOLO
SOUTH AFRICA	SOUT
SPAIN	SPAI
SRI LANKA	SRIL
ST. KITTS AND NEVIS	STKI
ST. LUCIA	STLU
ST. VINCENT & GRENS.	STVI
SURINAME	SURI
SWAZILAND	SWAZ
SWEDEN	SWED
SWITZERLAND	SWIT
THAILAND	THAI
TONGA	TONG
TRINIDAD AND TOBAGO	TRIN
TUNISIA	TUNI
TURKEY	TURK
UGANDA	UGAN
UKRAINE	UKRA
UNITED KINGDOM	UNIK
UNITED STATES	UNIS
URUGUAY	URUG
VENEZUELA. REP. BOL.	VENE
VIETNAM	VIET
ZAMBIA	ZAMB
ZIMBABWE	ZIMB