Evaluating the predictive content of leading indicators of inflation for South Africa

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Introduction

- The aim of this paper is to assess the predictive ability of a range of indicator variables for South African consumer price inflation, using recent developments in the literature on forecast evaluation as the basis for assessment.
- Inflation models suggest a number of potential indicator variables, many of which are popularly believed to be related to future developments in consumer price inflation.
- Ascertaining whether useful indicators of inflation exist requires that we go beyond the theory and examine the data.
- Comparison of direct, multistep forecasts from nested linear models.

The literature

- A large literature exists on forecasting inflation and output using asset prices and other indicator variables.
- Starting point here is the work by Cechetti (1995) and Cechetti, Chu and Steindel (2000): Cechetti et al, for example, found that no single indicator clearly and consistently improved on their autoregressive benchmark (10 of the 19 indicators they used performed worse than the autoregressive benchmark in more than 50 per cent of the estimation periods they considered).
- Subsequent work has applied this approach to other countries and extended the econometric approach in a number of interesting ways, but the basic result seems to remain intact. See eg Stock and Watson (2003), Marcellino (2006).

Issues arising from the literature

1. Distinction between in-sample and out-of-sample forecast evaluation
2. Data revisions, and particularly to the manner in which they are handled in the out-of-sample tests
3. The choice between using an iterated forecast or a direct forecast
4. Recent developments in forecast evaluation: tests of equal predictive accuracy proposed by Diebold and Mariano (1995) and West (1996), and by McCracken (2004) as well as the tests of forecast encompassing of Harvey et al (1998) and Clark and McCracken (2001)
5. Forecast combination

Econometric methodology

The pseudo out-of-sample (OOS) tests of predictability are based on the following autoregressive distributed lag (ARDL) model:

$$z_{t+h} = \beta_0 + \sum_{i=0}^{p-1} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{q-1} \gamma_i X_{t-i} + u_{t+h} \qquad (1)$$

where:

- $z_{t+h} = \sum_{i=1}^{h} \Delta Y_{t+i}$ is the h-step ahead value of inflation
- Y_t is the log-level of the CPI at time t and $\Delta Y_t = Y_t - Y_{t-1}$.
- X_t is the candidate indicator variable
- β_0, β_i, and γ_i are unknown parameters and u_{t+h} is the disturbance term.

Econometric methodology ...

Recursive scheme to generate the **OOS predictions for** z_{t+h}:

1. the total sample of T observations is divided into in-sample (the first F observations) and out-of-sample (the remaining G observations) components.
2. the OOS forecasts are generated from the **unrestricted** version of equation (1) and from the **restricted** version (i.e. excluding the potential predictor by setting $\gamma_i = 0$ for $i = 0, ..., q-1$).
3. The first unrestricted forecast using each indicator is generated by estimating equation (1) by OLS on the F in-sample observations ($\hat{z}_{UR,F+h}$). The restricted model is also estimated on the same sample, generating the benchmark AR forecast ($\hat{z}_{R,F+h}$).
4. The respective **forecast errors** are therefore given by $\hat{e}_{UR,F+h} = z_{F+h} - \hat{z}_{UR,F+h}$ and $\hat{e}_{R,F+h} = z_{F+h} - \hat{z}_{R,F+h}$.
5. This procedure is repeated using the first $F+1$ observations, then $F+2, \ldots$ generating $\{\hat{e}_{UR,t+h}\}_{t=F}^{T-h}$ and $\{\hat{e}_{R,t+h}\}_{t=F}^{T-h}$.

Forecast evaluation

The final step is to compare the pseudo out-of-sample forecasts generated by the restricted and unrestricted models.

- A commonly employed metric for undertaking this comparison is the **mean square forecast error (MSFE)** of the h-step ahead forecasts, ie $MS\hat{F}E_i = (T - F - h + 1)^{-1} \sum_{t=F}^{T-h} \hat{e}^2_{i,t+h}$ for $i = UR, R$.
- The **relative MSFE**: the ratio of the unrestricted model MSFE to the restricted model MSFE. If this ratio is less than one, the indicator is deemed to have performed better than the benchmark.
- To determine whether this outcome is not simply the result of sampling variability requires that tests of statistical significance are undertaken.

We consider four formal tests. Two of these are tests of **equal forecast accuracy**:

- To test whether the MSFE of the unrestricted model forecasts is significantly less than that of the restricted AR benchmark, the t-statistic of equal MSFE of Diebold and Mariano (1995) and West (1996), and the F-statistic of McCracken (2007) are used.
- Both tests are based on the loss differential $\hat{d}_{t+h} = \hat{e}^2_{UR,F+h} - \hat{e}^2_{R,F+h}$, and test the null that the unrestricted model OOS MSFE is equal to the restricted model OOS MSFE against the 1-sided alternative that he unrestricted model OOS MSFE is less than the restricted model OOS MSFE.
- The former test is denoted the **MSE-T** test, and the latter the **MSE-F** statistic.

Forecast evaluation . . .

Remaining two: use the concept of **forecast encompassing**:

- A composite OOS forecast of z_{t+h} may be constructed as a convex combination of the OOS forecasts of the restricted and unrestricted models

$$\hat{z}_{c,t+h} = \lambda \hat{z}_{UR,t+h} + (1-\lambda)\,\hat{z}_{R,t+h} \tag{2}$$

  where $0 \leq \lambda \leq 1$.
- $\lambda = 0$: the indicator variable does not contribute any useful information to the optimal composite forecast (the restricted model forecasts encompass those of the unrestricted - null hypothesis).
- $\lambda > 0$: the indicator variable contributes useful information to the optimal composite forecast (1-sided alternative).
- Harvey, Leybourne and Newbold (1998) provide a test for $\lambda = 0$ against the one-sided alternative that $\lambda > 0$, denoted the **ENC-T** test. A variant of this test is the Clark and McCracken (2001) the **ENC-F** test.

Note:

- When applied to **nested models**, Clark and McCracken (2005) show that the distributions of all of the tests have nonstandard distributions. While these distributions can be free of nuisance parameters when the forecast horizon is one, they are not free of nuisance parameters for longer forecast horizons.
- They suggest implementing a Kilian (1999)-type **bootstrap procedure** in order to obtain empirical distributions and undertake inference.
- Monte Carlo evidence: Clark and McCracken (2001, 2005) and Busetti et al (2009). Power of the tests may be ranked in descending order as: ENC-F, ENC-T, MSE-F and MSE-T.

Data

Table: Inflation and leading indicator data (1971:1 to 2008:4)

Indicator	Description	Transformation	Indicator	Description	Transformation
CPI	Consumer Price Index[1]	ΔL	PRIME	Prime interest rate	ΔL
BCCOINC	Coincident business cycle indicator	ΔL	REPO	Repo rate (synthetic)	ΔL
BCLEAD	Leading business cycle indicator	ΔL	RGDE	Real GDE	ΔL
BSPREAD	Term spread	*Level*	RGDP	Real GDP	ΔL
CAPU	Capacity utilisation	ΔL	RGDPGAP	Real GDP gap	ΔL, gap
CrExtPvt	Credit extension: Private	ΔL	RHOUSE	Real House Price Index (ABSA)	ΔL
CrExtTot	Credit extension: Total	ΔL	RJSEALL	Real JSE All-Share index	ΔL
EXRATE	Nominal exchange rate: R/US$	ΔL	RM1	Real M1 aggregate	ΔL
HFCE	Household consumption expenditure	ΔL	RM2	Real M2 aggregate	ΔL
HOUSE	House Price Index (ABSA)	ΔL	RM3	Real M3 aggregate	ΔL
IP	Industrial production	ΔL	ROIL	Real Brent crude price (US$)	ΔL
JSEALL	JSE All share index	ΔL	SBOND	Short govt bond rate: 0-3 yr	ΔL
LBOND	Long govt bond rate: 10 yr+	ΔL	ULC	Unit labour cost	ΔL
NEER	Nominal effective exchange rate	ΔL	WAGEN	Nominal wage rate	ΔL
OIL	Brent crude price (US$)	ΔL	WAGER	Real wage rate	ΔL
PPI	Production price index	ΔL			

[1] For metropolitan areas.

Results

- The stability of the results was considered by running the tests over two different sample periods. The recursive scheme was first used to generate predictions for the OOS period 1988:1 to 1998:4, and then rerun to generate new OOS forecasts for the period 1998:1 to 2008:4.
- The values of p and q were selected using the SIC from a maximum lag length of 8 in each case (to ensure that the indicator variable appears in the unrestricted model, a minimum lag length of 1 was imposed).
- The forecast horizons used for the tests are 1, 2, 4 and 8 quarters ahead (ie $h = 1, 2, 4, 8$)

Results

Pseudo out-of-sample test results: CPI inflation

	1-quarter ahead		2-quarters ahead		4-quarters ahead		8-quarters ahead	
	88:1-98:4	98:1-08:4	88:1-98:4	98:1-08:4	88:1-98:4	98:1-08:4	88:1-98:4	98:1-08:4
Exchange rate: R/US$ (ΔL)								
p,q	0,1	4,1	4,1	4,1	3,1	3,1	0,1	3,1
Relative MSFE	1.01	0.91	0.93	0.90	0.96	0.93	1.01	0.96
MSE-T	-0.43 (0.41)	1.35 (0.02)	2.88 (0.00)	1.02 (0.08)	1.24 (0.09)	0.70 (0.15)	-0.80 (0.48)	0.83 (0.16)
MSE-F	-0.53 (0.51)	4.31 (0.00)	3.26 (0.03)	4.53 (0.01)	1.81 (0.09)	3.07 (0.03)	-0.28 (0.40)	1.68 (0.06)
ENC-T	0.08 (0.37)	2.07 (0.01)	3.53 (0.00)	1.45 (0.09)	1.85 (0.08)	1.00 (0.17)	0.13 (0.37)	1.09 (0.20)
ENC-F	0.05 (0.37)	3.40 (0.00)	2.05 (0.06)	3.50 (0.01)	1.36 (0.15)	2.28 (0.04)	0.02 (0.39)	1.10 (0.10)
HFCE (ΔL)								
p,q	0,1	4,1	4,1	4,1	3,1	3,1	0,1	3,1
Relative MSFE	1.01	0.99	1.01	1.00	1.00	1.00	1.01	0.97
MSE-T	-1.76 (0.92)	0.68 (0.11)	-1.60 (0.88)	0.39 (0.23)	-0.21 (0.33)	0.75 (0.17)	-1.94 (0.88)	2.13 (0.05)
MSE-F	-0.39 (0.44)	0.29 (0.16)	-0.25 (0.38)	0.04 (0.29)	-0.10 (0.31)	0.18 (0.24)	-0.38 (0.51)	0.99 (0.13)
ENC-T	-1.72 (0.95)	0.79 (0.15)	-1.59 (0.93)	0.46 (0.30)	-0.12 (0.44)	0.81 (0.24)	-1.92 (0.90)	2.18 (0.08)
ENC-F	-0.19 (0.61)	0.17 (0.25)	-0.12 (0.51)	0.02 (0.40)	-0.03 (0.43)	0.10 (0.32)	-0.18 (0.64)	0.52 (0.18)
House prices (ΔL)								
p,q	4,1	4,1	4,1	4,1	3,1	3,1	0,1	3,1
Relative MSFE	1.03	1.00	1.07	1.00	1.06	1.00	1.02	1.01
MSE-T	-1.46 (0.83)	-0.29 (0.39)	-1.23 (0.71)	-0.13 (0.34)	-1.51 (0.80)	-0.13 (0.34)	-1.56 (0.75)	-0.81 (0.52)
MSE-F	-1.39 (0.73)	-0.13 (0.34)	-2.82 (0.78)	-0.05 (0.32)	-2.15 (0.57)	-0.04 (0.31)	-0.59 (0.40)	-0.28 (0.38)
ENC-T	-1.34 (0.87)	-0.19 (0.50)	-1.21 (0.80)	0.03 (0.41)	-1.45 (0.85)	-0.01 (0.40)	-1.52 (0.83)	-0.78 (0.62)
ENC-F	-0.61 (0.84)	-0.04 (0.46)	-1.27 (0.88)	0.01 (0.42)	-0.97 (0.73)	-0.00 (0.40)	-0.28 (0.50)	-0.13 (0.49)

Note: p and q are the lags in the ARDL equation. Bootstrapped p-values are reported in parentheses.

OOS: 1998:01 - 2008:04

	k=1	k=2	k=4	k=8
Relative MSFE:				
BCCOINC	0.979	0.991	0.984	0.963
BCLEAD	1.003	1.000	0.968	0.950
BSPREAD	0.995	1.001	0.995	0.924
CAPU	0.971 *	0.975	0.996	0.993
CREXTPVT	0.991	1.006	0.996	0.972
CREXTTOT	0.980 *	1.001	1.002	0.982
EXRATE (R/US$)	0.909 ***	0.903 **	0.929 **	0.955 *
HFCE	0.993	0.999	0.996	0.973
HOUSE	1.003	1.001	1.001	1.008
IP	0.894 **	0.945 *	0.950 *	0.913 **
JSEALL	0.961 **	0.975	0.945 *	0.945 *
LBOND	0.869 ***	0.949 **	0.934 **	0.952 *
NEER	0.855 ***	0.869 ***	0.916 **	0.951 *
OIL	1.009	1.020	1.009	1.007
PPI	0.848 ***	0.844 **	0.789 **	0.811 *
PRIME	0.866 ***	0.928 **	0.979	0.984
REPO	0.984	1.005	1.005	1.011
RGDE	0.981	0.990	1.002	0.997
RGDP	0.981	1.002	1.001	0.987
RGDPGAP	0.998	1.010	0.999	0.972
RHOUSE	1.000	0.997	1.003	1.008
RJSEALL	0.961 *	0.975	0.945 *	0.945
RM1	1.012	0.964	0.936 *	0.963
RM2	0.996	0.997	0.950 *	0.956
RM3	0.968	0.969	0.931	0.955
ROIL	1.009	1.020	1.009	1.007
SBOND	0.890 ***	0.957 *	0.958 *	0.969
ULC	1.020	1.040	1.048	1.050
WAGEN	0.982	0.979	0.982	0.995
WAGER	0.991	1.006	0.999	1.001
Min:	0.848	0.844	0.789	0.811
Max:	1.020	1.040	1.048	1.050

OOS: 1988:01 - 1998:04

	k=1	k=2	k=4	k=8
Relative MSFE:				
BCCOINC	1.010	0.988	1.056	1.054
BCLEAD	1.008	1.017	1.000	1.007
BSPREAD	1.047	1.034	1.059	1.127
CAPU	1.017	1.112	1.181	1.049
CREXTPVT	0.978	0.936 *	0.921 *	0.918
CREXTTOT	1.012	0.978	0.954	0.970
EXRATE (R/US$)	1.012	0.928 *	0.957	1.008
HFCE	1.009	1.006	1.002	1.011
HOUSE	1.033	1.072	1.057	1.017
IP	0.986	0.984	1.021	1.016
JSEALL	0.974 *	0.980	0.998	1.009
LBOND	0.905 **	0.884 ***	0.971 *	0.993
NEER	0.992	0.973	0.969	0.986
OIL	1.014	0.976	0.991	1.018
PPI	0.690 ***	1.005	0.959	1.181
PRIME	1.007	0.998	0.991	1.018
REPO	1.020	1.005	1.005	1.025
RGDE	1.007	0.985	1.018	1.017
RGDP	1.010	0.933 *	0.973	1.015
RGDPGAP	1.021	1.403	1.436	1.717
RHOUSE	0.992	1.078	1.049	1.032
RJSEALL	0.991	0.980	0.998	1.006
RM1	0.904 **	1.010	1.001	1.018
RM2	0.983	1.004	0.954	1.014
RM3	0.934	1.000	0.960	1.050
ROIL	1.018	0.976	0.991	1.019
SBOND	0.927 **	0.964	0.978	0.996
ULC	0.838 ***	0.996	1.016	0.981
WAGEN	0.924 **	1.010	1.011	0.990
WAGER	1.010	1.013	1.006	0.994
Min:	0.690	0.884	0.921	0.918
Max:	1.047	1.403	1.436	1.717

k=1:

Relative MSFE:	**1988:01 - 1998:04**	**1998:01 - 2008:04**
BCCOINC	1.010	0.979
BCLEAD	1.008	1.003
BSPREAD	1.047	0.995
CAPU	1.017	0.971 *
CREXTPVT	0.978	0.991
CREXTTOT	1.012	0.980 *
EXRATE (R/US$)	1.012	0.909 ***
HFCE	1.009	0.993
HOUSE	1.033	1.003
IP	0.986	0.894 **
JSEALL	0.974 *	0.961 **
LBOND	0.905 **	0.869 ***
NEER	0.992	0.855 ***
OIL	1.014	1.009
PPI	0.690 ***	0.848 ***
PRIME	1.007	0.866 ***
REPO	1.020	0.984
RGDE	1.007	0.981
RGDP	1.010	0.981
RGDPGAP	1.021	0.998
RHOUSE	0.992	1.000
RJSEALL	0.991	0.961 *
RM1	0.904 **	1.012
RM2	0.983	0.996
RM3	0.934	0.968
ROIL	1.018	1.009
SBOND	0.927 **	0.890 ***
ULC	0.838 ***	1.020
WAGEN	0.924 **	0.982
WAGER	1.010	0.991
Min:	0.690	0.848
Max:	1.047	1.020

k=2:

Relative MSFE:	1988:01 - 1998:04	1998:01 - 2008:04
BCCOINC	0.988	0.991
BCLEAD	1.017	1.000
BSPREAD	1.034	1.001
CAPU	1.112	0.975
CREXTPVT	0.936 *	1.006
CREXTTOT	0.978	1.001
EXRATE (R/US$)	0.928 *	0.903 **
HFCE	1.006	0.999
HOUSE	1.072	1.001
IP	0.984	0.945 *
JSEALL	0.980	0.975
LBOND	0.884 ***	0.949 **
NEER	0.973	0.869 ***
OIL	0.976	1.020
PPI	1.005	0.844 **
PRIME	0.998	0.928 **
REPO	1.005	1.005
RGDE	0.985	0.990
RGDP	0.933 *	1.002
RGDPGAP	1.403	1.010
RHOUSE	1.078	0.997
RJSEALL	0.980	0.975
RM1	1.010	0.964
RM2	1.004	0.997
RM3	1.000	0.969
ROIL	0.976	1.020
SBOND	0.964	0.957 *
ULC	0.996	1.040
WAGEN	1.010	0.979
WAGER	1.013	1.006
Min:	0.884	0.844
Max:	1.403	1.040

k=4:

Relative MSFE:	**1988:01 - 1998:04**	**1998:01 - 2008:04**
BCCOINC	1.056	0.984
BCLEAD	1.000	0.968
BSPREAD	1.059	0.995
CAPU	1.181	0.996
CREXTPVT	0.921 *	0.996
CREXTTOT	0.954	1.002
EXRATE (R/US$)	0.957	0.929 **
HFCE	1.002	0.996
HOUSE	1.057	1.001
IP	1.021	0.950 *
JSEALL	0.998	0.945 *
LBOND	0.971 *	0.934 **
NEER	0.969	0.916 **
OIL	0.991	1.009
PPI	0.959	0.789 **
PRIME	0.991	0.979
REPO	1.005	1.005
RGDE	1.018	1.002
RGDP	0.973	1.001
RGDPGAP	1.436	0.999
RHOUSE	1.049	1.003
RJSEALL	0.998	0.945 *
RM1	1.001	0.936 *
RM2	0.954	0.950 *
RM3	0.960	0.931
ROIL	0.991	1.009
SBOND	0.978	0.958 *
ULC	1.016	1.048
WAGEN	1.011	0.982
WAGER	1.006	0.999
Min:	0.921	0.789
Max:	1.436	1.048

k=8:

Relative MSFE:	1988:01 - 1998:04	1998:01 - 2008:04
BCCOINC	1.054	0.963
BCLEAD	1.007	0.950
BSPREAD	1.127	0.924
CAPU	1.049	0.993
CREXTPVT	0.918	0.972
CREXTTOT	0.970	0.982
EXRATE (R/US$)	1.008	0.955 *
HFCE	1.011	0.973
HOUSE	1.017	1.008
IP	1.016	0.913 **
JSEALL	1.009	0.945 *
LBOND	0.993	0.952 *
NEER	0.986	0.951 *
OIL	1.018	1.007
PPI	1.181	0.811 *
PRIME	1.018	0.984
REPO	1.025	1.011
RGDE	1.017	0.997
RGDP	1.015	0.987
RGDPGAP	1.717	0.972
RHOUSE	1.032	1.008
RJSEALL	1.006	0.945
RM1	1.018	0.963
RM2	1.014	0.956
RM3	1.050	0.955
ROIL	1.019	1.007
SBOND	0.996	0.969
ULC	0.981	1.050
WAGEN	0.990	0.995
WAGER	0.994	1.001
Min:	0.918	0.811
Max:	1.717	1.050

Forecast combination: Simple

Relative MSFEs	OOS: 1998:01 - 2008:04			
	k=1	**k=2**	**k=4**	**k=8**
#OOS forecasts	43	42	40	36
Leading indicators:				
Min:	0.848	0.844	0.789	0.811
Max:	1.020	1.040	1.048	1.050
Average:	0.963	0.977	0.972	0.970
Forecast combination:				
Mean	0.946	0.963	0.961	0.960
Median	0.970	0.978	0.975	0.970
Trimmed mean	0.953	0.964	0.960	0.960

Forecast combination

Relative MSFEs	OOS: 1998:01 - 2008:04			
	k=1	k=2	k=4	k=8
#OOS forecasts (after first 20 holdout)	23	22	20	16
Individual leading indicators:				
Min:	0.812	0.831	0.712	0.583
Max:	1.056	1.153	1.246	1.274
Average:	0.960	0.982	0.977	0.962
Forecast combination:				
Mean	0.945	0.965	0.959	0.944
Median	0.968	0.978	0.971	0.953
Trimmed mean	0.951	0.964	0.957	0.943
DMSFE (delta=1.0)	0.942	0.963	0.958	0.943
DMSFE (delta=0.90)	0.940	0.959	0.957	0.944
C(2,PB)	0.937	0.955	0.965	0.940
C(3,PB)	0.911	0.943	0.974	0.931

Summary

The paper has evaluated the predictive content of a set of leading indicators using a pseudo out-of-sample method at forecast horizons of up to eight quarters. The results reveal:

- Certain indicators have at times had statistically significant predictive content for the South African CPI inflation rate.
- These include the exchange rate, bond yields, share prices, the PPI, and IP;
- BUT there is little evidence that indicators perform well in both out-of-sample periods
- Forecast combination techniques seem to consistently improve performance relative to the AR benchmarks.

Notes

- "Intuitively, with nested models, the null hypothesis that the restrictions imposed in the benchmark model are true implies that the population errors of the competing forecasting models are exactly the same. This in turn implies, for example, that the population difference between the competing models mean square forecast errors is exactly zero with zero variance" (Clark and McCracken, 2005, 370).
- The results in West (1996) require that under the null, the population-level long run variances be positive.
- "Simulation evidence in Clark and McCracken (2001, 2003, 2005b), McCracken (2004), Clark and West (2005a, 2005b)) and Corradi and Swanson (2005) indicates that in MSPE comparisons in nested models the usual statistic is non-normal not only in a technical but in an essential practical sense: use of standard critical values usually results in very poorly sized tests, with far too few rejections. As well, the usual statistic has very poor power." (West, 2006)

Notes . . .

- When applied to **nested models**, the distributions of the MSE-T and MSE-F statistics have a non-standard, pivotal asymptotic distribution for $h = 1$ (McCracken, 2007). For $h > 1$, Clark and McCracken (2005) show that the limiting distribution is not asymptotically pivotal, and suggest implementing a Kilian (1999)-type **bootstrap procedure** in order to undertake inference.
- For nested models, the distribution of both the ENC-T and ENC-F statistics are nonstandard for $h = 1$ (Clark and McCracken, 2001) and non-standard and not asymptotically pivotal for $h > 1$ (Clark and McCracken, 2005). Again it is recommended that inference is based on a bootstrap procedure.