Fiscal sustainability and the fiscal reaction function for South Africa

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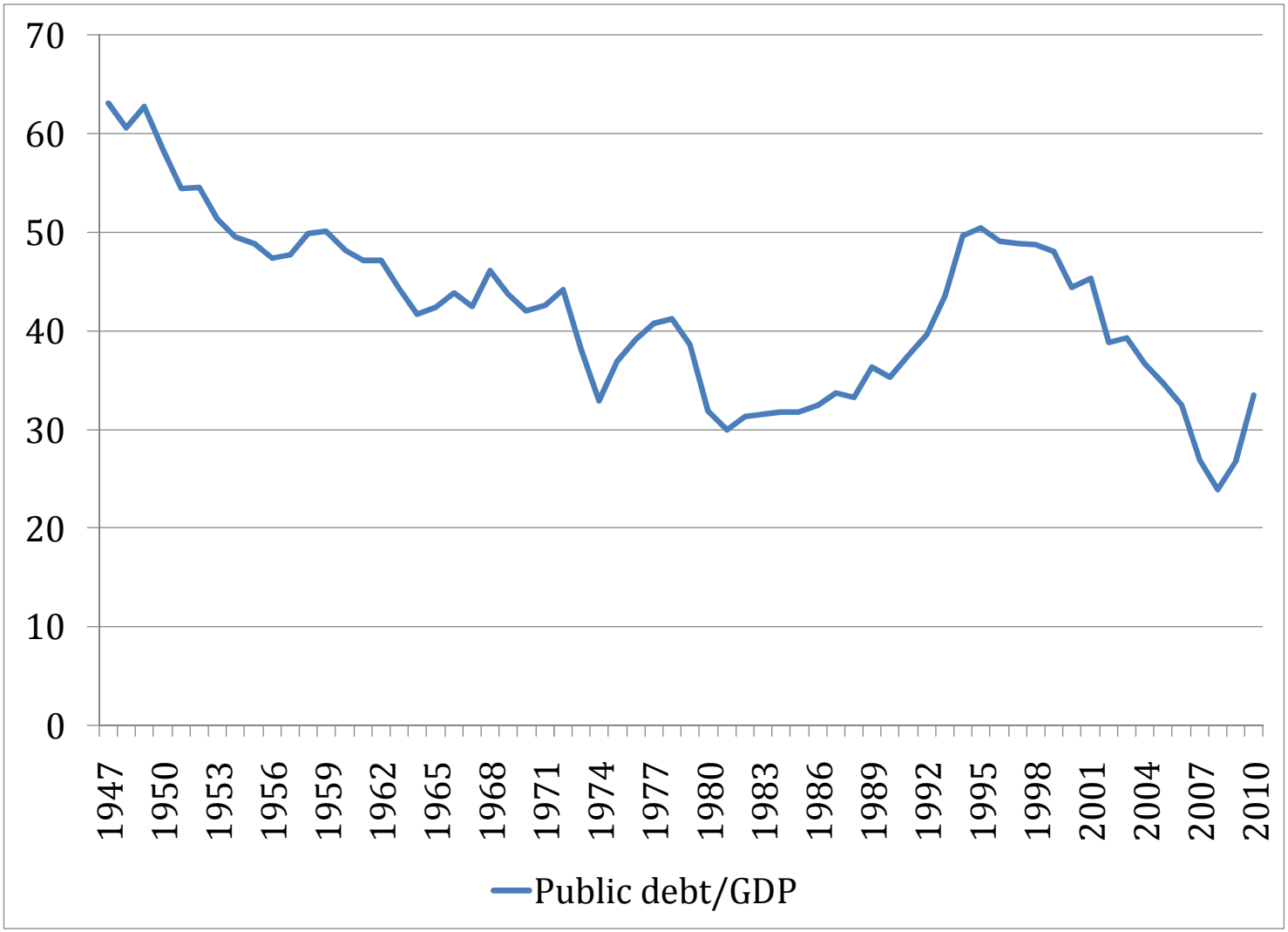
Introduction

- Having reduced its debt burden over the past thirteen years, the South African government again finds itself facing rising debt.
- Falling tax revenues brought on by the 2008/9 global financial crisis.
- Understanding how the South African government has in the past reacted to the variation in public debt aids the assessment of:
    - The sustainability of fiscal policy and
    - The ambitiousness of government's proposed fiscal consolidation.
- How does the South African government react to changes in its debt position?
    - Fiscal reaction functions estimated using various methods (OLS, VAR, TAR, GMM, State-Space modelling and VECM).
- Since 1946 the South African government ran a sustainable fiscal policy, by reducing the primary deficit or increasing the surplus in response to rising debt.
- Looking ahead: Considers the use of fiscal reaction functions to forecast the debt/GDP ratio and gauging the likelihood of achieving policy goals.
    - Done with the aid of probabilistic simulations and fan charts.

Figure 1 – Public debt/GDP in South Africa (percent)



Fiscal reaction functions and debt sustainability – the basics

- Fiscal reaction functions: The reaction of the primary balance/GDP ratio to changes in the one-period lagged public debt/GDP ratio.
- According to Bohn (1995, 2007) this represents an error correction mechanism
- If the public debt/GDP ratio increases, government should respond by improving the primary balance, to arrest and even reverse the rise in the public debt/GDP ratio.

- Budget constraint of government (cf. Bohn 1998, 2007, Gali and Perotti 2003, De Mello 2005):

  $D_t = D_{t-1} + iD_{t-1} - B_t$ (1)

  where: D: Public debt, i: Nominal interest rate on government bonds, B: Primary balance (+ surplus; - deficit)

- Use Equation (1) to derive Equation (3):

$$\Delta(D/Y)_t = ((r - g)/(1 + g))(D/Y)_{t-1} - (B/Y)_t \qquad (3)$$

where: r: real interest rate, g: real economic growth rate, Y: nominal GDP

- To ensure the debt/GDP ratio remains unchanged:

$$(B/Y)_t = ((r - g)/(1 + g))(D/Y)_{t-1} \qquad (4)$$

- If debt levels are considered acceptable, Equation (4) can be interpreted as a fiscal rule. Rule defines the primary balance/GDP ratio required to keep to such a debt/GDP target.
- To study the actual behaviour of government, one can estimate a fiscal reaction function:

$$(B/Y)_t^{Act} = \alpha(D/Y)_{t-1}^{Act} + \varepsilon_t \qquad (5)$$

- One might conjecture that α should be on average equivalent to $(r - g)/(1 + g)$.

- Include intercept, inertia term and output gap ($\hat{y}$):

$$(B/Y)_t^{Act} = \alpha_1 + \alpha_2(B/Y)_{t-1}^{Act} + \alpha_3(D/Y)_{t-1}^{Act} + \alpha_4(\hat{y})_t + \varepsilon_t \qquad (6)$$

Data:

- All data sourced from SARB
- Sample either 1974-2008 or 1946-2008
- Public debt/GDP data (national government) from 1946.
- The South African government published primary balance data for a while in the late 1990s in its Budget Review, but ceased its publication subsequently.
- Primary balance data (national government) from 1974 based on GFS data.
- Primary balance data (general government) from 1946 based on SNA data.
- Output gap constructed using Hodrick-Prescott filter and a Kalman filter

Stationarity of data

- Stationarity of data a problem

  $(D/Y)_t = ((1 + r)/(1 + g))(D/Y)_{t-1} - (B/Y)_t$ (7)

- Standard stationarity tests could have difficulty rejecting the null hypothesis of a unit root (Bohn 1998:955).
- For instance, if r = 2 percent and g = 4 percent, then $((1 + r)/(1 + g)) = 0.98$
- Use various methods:
  - Firstly, use OLS, VAR and GMM assuming stationarity.
  - Secondly use State-Space and TAR models assuming non-linearities.
  - Thirdly VECM assuming non-stationary.

Table 1 – Stationarity test for the Debt/GDP ratio and the primary balance/GDP ratio

1946-2008		1974-2008	
The Debt/GDP ratio			
ADF test (OLS)		**ADF test (OLS)**	
H_0 : D/Y is I(1)	**H_0 : D/Y is I(2)**	**H_0 : D/Y is I(1)**	**H_0 : D/Y is I(2)**
$(D/Y)_{t-1}$	**$d(D/Y)_{t-1}$**	**$(D/Y)_{t-1}$**	**$d(D/Y)_{t-1}$**
-0.019**		-0.13	-0.447**
[-2.51]		[-1.062]	[-2.178]
KPSS test		**KPSS test**	
H_0 : D/Y is I(0) (Test statistic)	**H_0 : D/Y is I(1) (Test statistic)**	**H_0 : D/Y is I(0) (Test statistic)**	**H_0 : D/Y is I(1) (Test statistic)**
0.58^{++}	0.18	0.16	?
ADF-type regression (GMM) (H_0 : D/Y is I(1))		**ADF-type regression (GMM) (H_0 : D/Y is I(1))**	
Without control variable		**Without control variable**	
$(D/Y)_{t-1}$		**$(D/Y)_{t-1}$**	
$-0.024^{###}$		-0.021	
[-3.46]		[-1.351]	
With control variable		**With control variable**	
$(D/Y)_{t-1}$	**$(\hat{y})$**	**$(D/Y)_{t-1}$**	**$(\hat{y})$**
$-0.015^{#}$	-0.446	$-0.035^{###}$	-1.04
[-1.767]	(0.042)	[-3.34]	(0.000)

	The primary balance/GDP ratio (SNA data)				**The primary balance/GDP ratio (GFS data)**	
	1946-2008		**1974-2008**		**1974-2008**	
	Level	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**
ADF test t and p value	-2.642*** (0.009)		-2.203** (0.029)		-3.55*** (0.003)	
KPSS test value	0.87^{+++}	0.22	0.58^{++}	0.28	0.50^{++}	0.26

Estimation results: OLS, TAR, VAR and GMM models

Table 2 - Fiscal reaction functions for South Africa

	OLS#	OLS##	VAR#	VAR##	TAR#	TAR##	GMM#	GMM##	GMM#	GMM##
Data	**GFS**	**GFS**	**GFS**	**GFS**	**GFS**	**GFS**	**GFS**	**GFS**	**SNA**	**SNA**
$(B/Y)_{t-1}$	0.75	0.77	0.53	0.57	0.68	0.73	0.64	0.48	0.63	0.28
	[2.87]	[8.19]			[6.89]	[8.11]	[5.06]	[3.65]	[5.51]	[2.10]
$(D/Y)_{t-1}$	0.04	0.02	0.05	0.03	0.04	0.02	0.01	0.02	0.01	0.03
	[2.76]	[1.66]			[2.80]	[1.61]	[2.09]	[2.10]	[2.43]	[2.38]
$(\hat{y})_{t-1}$	0.25	0.22	0.18	0.29			0.28	0.33	0.35	0.67
	[2.24]	[2.26]					[1.72]	[1.30]	[2.32]	[2.52]
$(\hat{y})_{t-1}$ **positive**					0.21	0.10				
					[1.10]	[0.77]				
$(\hat{y})_{t-1}$ **Negative**					0.38	0.33				
					[1.72	[2.63]				
C	0.04	0.03	0.05	0.04	0.02	0.03				
	[7.67]	[1.97]			[3.11]	[2.10]				
Adj R-sq	0.71	0.72	0.60	0.74	0.74	0.74	0.63	0.63	0.58	0.25

[#] Estimated with HP-generated output gap; [##] Estimated with a Kalman filter-generated output gap.

The VECM estimates

- Primary balance/GDP ratio and debt/GDP ratio included in long-run component of the model
- Output gap, given its stationarity, included in short-run dynamics of the model.
- The information criteria: no lags should be included in the short-run component of the model. Analysis nevertheless includes one lag: discern possible short-run effects in VECM-Granger.

Table 3 – Unrestricted Cointegration Rank (Trace) Test

National accounts primary balance and national debt

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None *	0.402	17.47	15.5	0.025
At most 1	0.015	0.51	3.84	0.475

* Rejection of null hypothesis: Trace test indicates one cointegrating equation at the 5 percent level

Table 4 – VECM results

Cointegrating Equation:		
$(B/Y)_{t-1}$	1	
$(D/Y)_{t-1}$	-0.131	
	[-2.144]	
C	0.046	
Error Correction Equation:	**D(B/Y)**	**D(D/Y)**
Cointegrating Equation	-0.445	-0.552
	[-3.285]	[-2.232]
$D(B/Y)_{t-1}$	0.253	-0.177
	[1.639]	[-0.627]
$D(D/Y)_{t-1}$	-0.074	-0.063
	[-0.69]	[-0.323]
C	0.002	-0.009
	[0.768]	[-2.055]
($\hat{y}$)	0.096	-0.512
	[0.920]	[-2.687]
Adj. R-sq	0.28	0.39
Weak exogeneity test χ^2 (prob)	0.001	0.023
$D(D/Y)_{t-1}$ → $D(B/Y)_{t-1}$ (prob)*	0.49	
$D(B/Y)_{t-1}$ → $D(D/Y)_{t-1}$ (prob)*	0.53	
Serial corr LM (1)(lag 1) (prob)	0.19	
Serial corr LM (1)(lag 2) (prob)	0.39	
Serial corr LM (1)(lag 3) (prob)	0.20	

Values in [ ] represent t values, * Probability of the VECM Grange causality test

Table 5 – VAR in levels version of VECM results

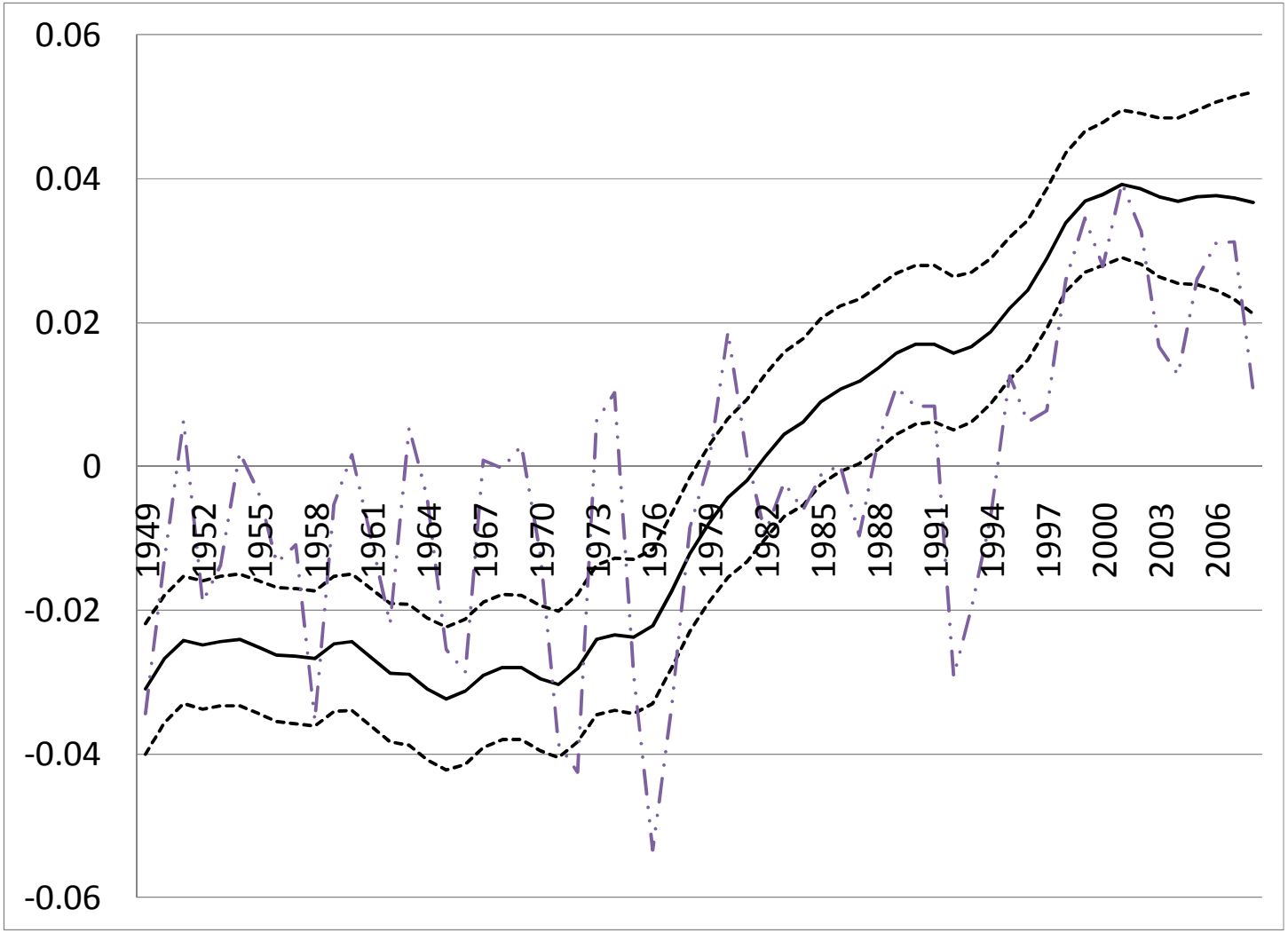
Parameters		Sum of parameters	
$(B/Y)_{t-1}$	0.808	**(B/Y)**	0.555
$(D/Y)_{t-1}$	-0.016	**(D/Y)**	0.058
$(B/Y)_{t-2}$	-0.253	**($\hat{y}$)**	0.096
$(D/Y)_{t-2}$	0.074	**C**	-0.020
$(\hat{y})_{t-1}$	0.096		
C	-0.020		

The State-Space estimates

Table 6 - Fiscal reaction function (State-space End states)

	Fixed Coefficient
$(B/Y)_{t-1}$	0.286 (0.071)
$(\hat{y})$	0.311 (0.001)
	End State
$(D/Y)_{t-1}$	0.037 (0.03)

Figure 4 – Public debt/GDP state variable (line with confidence interval) and primary balance (dot-dash line)



Uses of the fiscal reaction for debt forecasting and policy design

The reaction function as basis for probabilistic debt modelling

- Deterministic scenario testing: project future debt paths by choosing exogenous values for growth and interest rates.
  - Assumes static interplay of variables,
  - Produces relatively few outcomes (e.g. high-growth vs. low-growth scenarios), to which one cannot ascribe probabilities.
- By producing a distribution (represented by a fan chart) of a thousand possible debt/GDP outcomes, method used here captures the inherently probabilistic nature of risk analysis.
- Original method of Celasun *et al.* (2006)
- It projects debt service costs and by extension the budget balance using a calibrated, symmetrical fiscal reaction function.
- Extends Celasun *et al.* (2006): Produce fan chart with asymmetrical reaction to output gap.

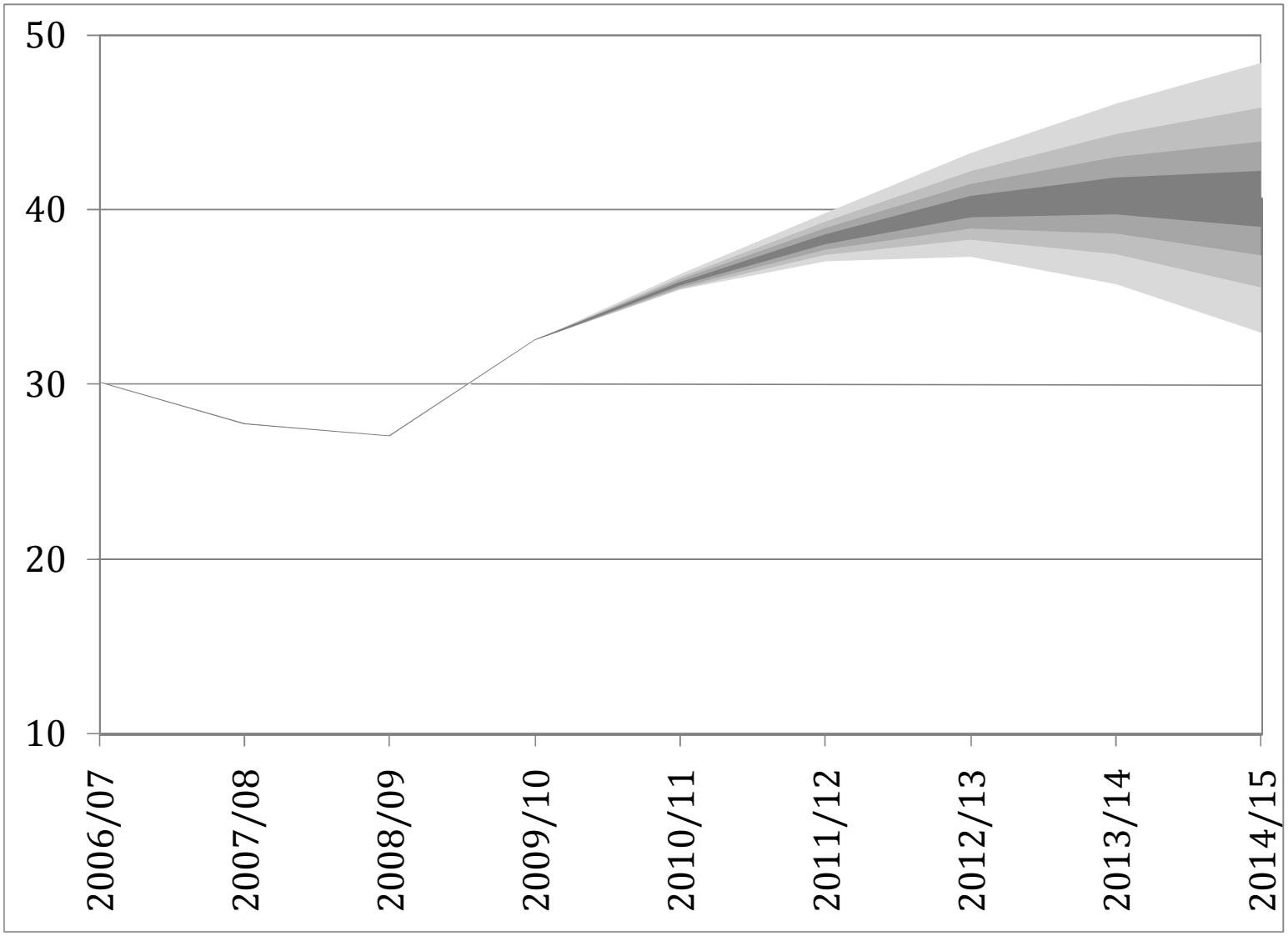
Table 7 – Parameters for the fan-chart model

	Symmetrical model	Asymmetrical model
$(B/Y)_{t-1}$	0.75	0.68
$(\hat{y})_{t-1}$	0.25	
$(\hat{y})_{t-1}$ **Positive**		0.21
$(\hat{y})_{t-1}$ **Negative**		0.38
$(D/Y)_{t-1}$	0.04	0.03
C	0.04	0.04

- Estimate VAR to produce jointly a distribution of real interest rates, growth and inflation (GDP deflator) outcomes. Sample: 1995Q1 to 2010Q1; 2 lags (Akaike Info Criteria).
- Analysis separately simulates paths for real GDP and real interest rates to extract statistical properties of innovations to these series.
- Instead of assuming normality, bootstrapped draws on the residuals were taken.

- Forward looking part: bootstrapped draws and parameters of VAR used to forecast 1000 possible combinations of economic growth rates and interest rates for the next 5 fiscal years.
- To estimate potential GDP: HP filter used around median outcome of the 1000 bootstrapped outcomes generated for real GDP.
- 1000 output gaps are fed into the fiscal reaction function from Table 7, to forecast a distribution of primary balance outcomes.
- Combination of projected fiscal and real variables, along with the initial value of public debt, yields a distribution of future ratios of public debt/GDP ratio.

Figure 6 –Debt/GDP for South Africa, 2006/7 – 2014/15 (percent)



- Figure 6 shows the median forecast for debt/GDP increasing from 28 percent of GDP in 2009/10 to 41 percent of GDP in 2014/15.
- South Africa is likely to approach its 2000/1 level in the five years following 2009/10.
- Probability that debt-to-GDP ratio will stay below the 50 percent mark is over 90 percent.
- Fan chart model extended: Business cycle-dependent asymmetric reaction to output gap
- Median debt outcome of around 38 percent of GDP and debt ratio stabilisation in 2014/15.
- Fan chart asymmetrically distributed around mean with greater dispersion below the median.
- Indicates greater ‘downside’ risk to the projections.
- Potential for a large positive surprise, understood as a result well below a 40 percent debt/GDP ratio, exceeding the potential for a large adverse surprise.
- Even in the most conservative simulation, the fan-chart suggests that there is a fairly low chance that debt will breach 50 percent of GDP by fiscal year 2014/15.

Figure 7 – Debt/GDP for South Africa calibrated for differentiated reactions to positive and negative output gaps, 2006/7 – 2014/15 (percent)

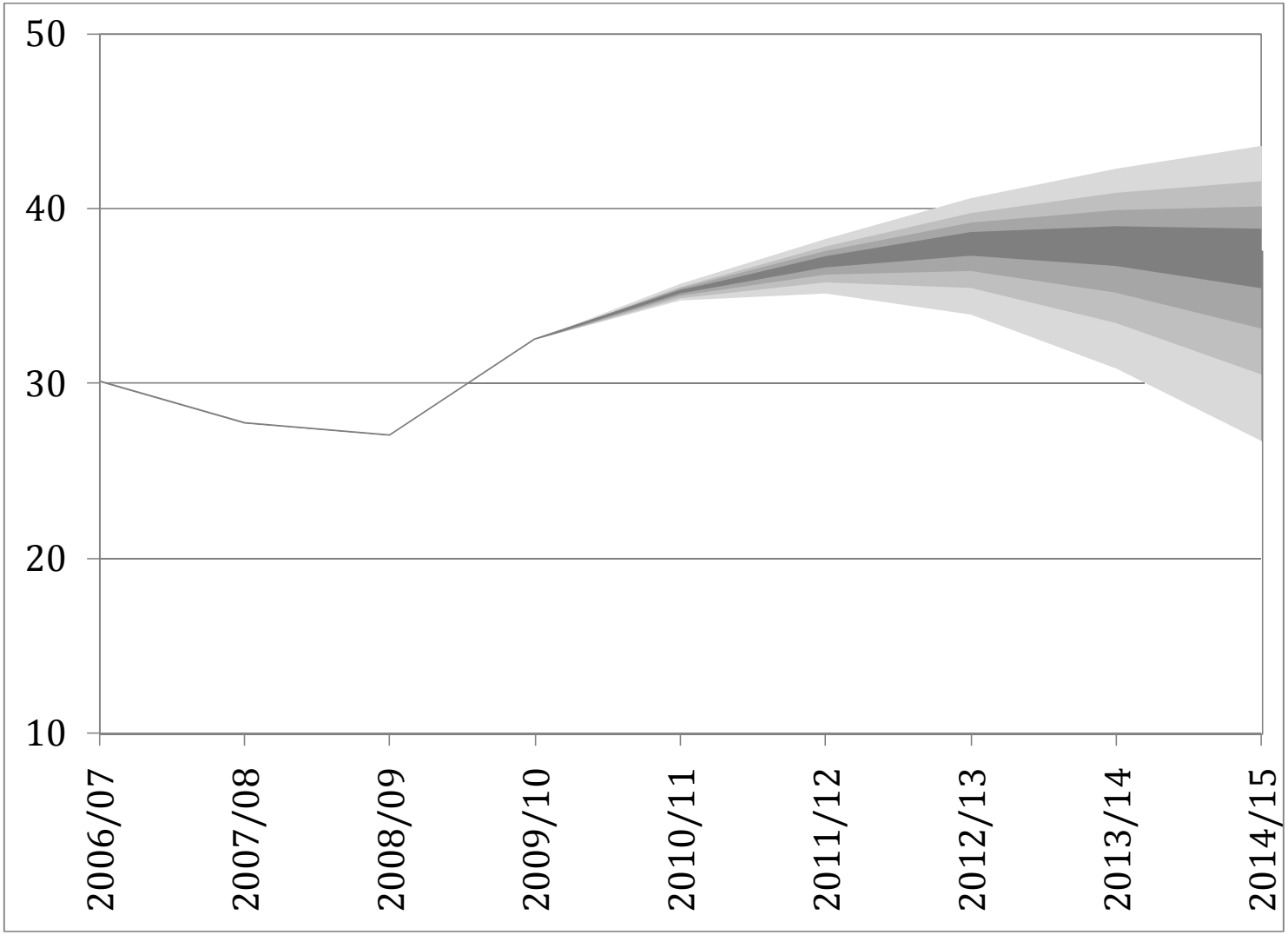
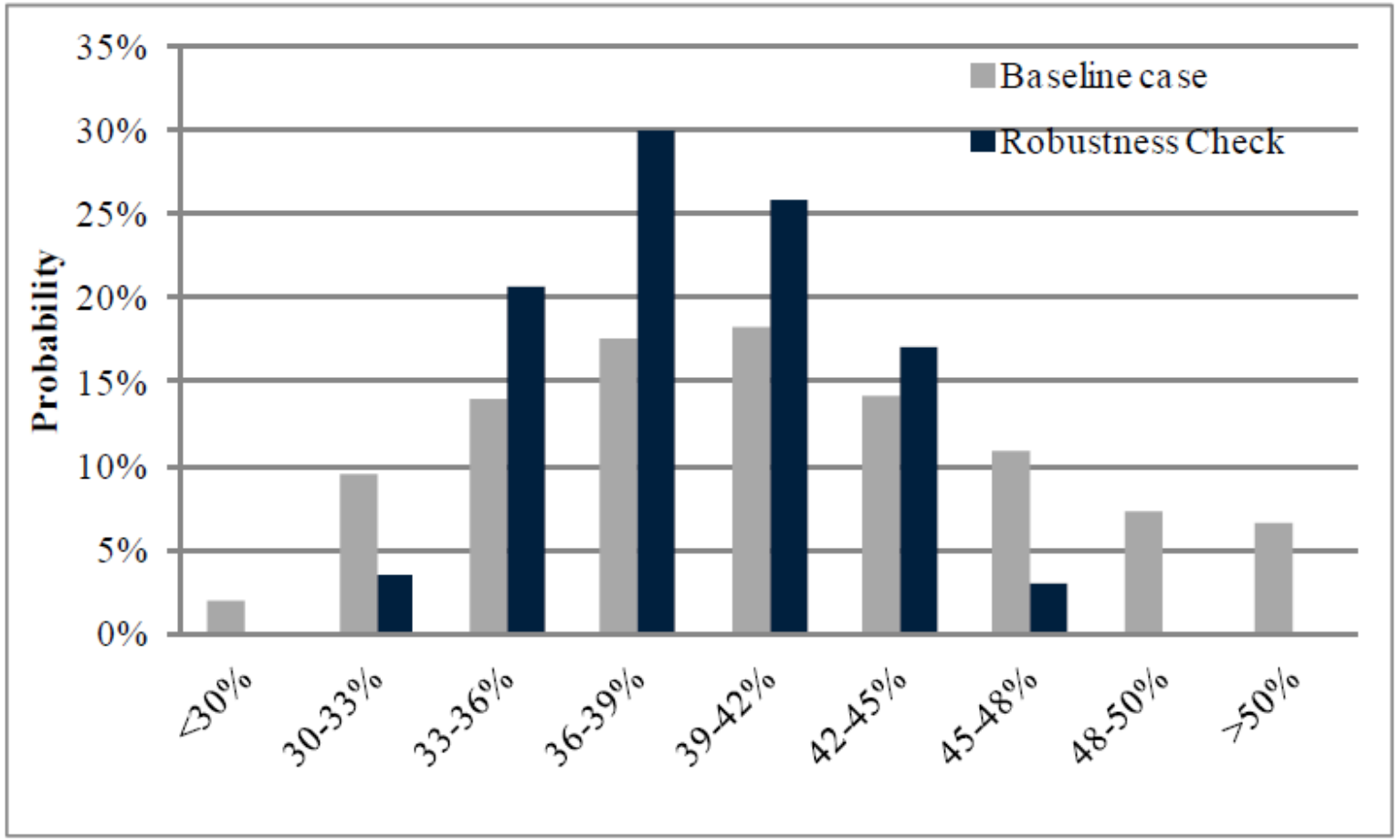


Figure 8 – Distribution of possible debt to GDP outcomes, 2015/16 (percent)



Conclusion

- Use of a variety of techniques: OLS, VAR, GMM, TAR, State-Space modelling and VECM.
- From all these models the same message emerges: The South African government tightened fiscal policies in the face of shocks to the debt/GDP position.
- From the State-Space estimations: reaction increased over time as circumstances required it.
- If the past is a guide to the future, than there is little risk that public debt will become too high.
- Projected debt and budget balance distributions indicate that published fiscal targets are not unduly ambitious by historical standards, and targets could even be overshot (i.e. the debt/GDP ratio can be lower than expected).
- In future, could be useful to complement point forecasts and policy targets with a broad probabilistic assessment of the risks around a central projection.