Some issues in modelling and forecasting inflation in South Africa

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1. Introduction

This invited overview paper draws on our South African and United States (US) inflation modelling and forecasting experience. The current global crisis highlights the importance for policy-makers of having good models for forecasting inflation. Central banks' caution about inflation risks (expressed, for example, in the Federal Reserve minutes of 16 September 2008, released on 7 October, and the European Central Bank's 2 October 2008 statement about the decision to leave interest rates unchanged) may have been understandable, given the inflation shocks of 2008. However, it suggested the major central banks were 'behind the curve'.

Forecasting inflation is notoriously difficult. There have been big structural shifts in the world economy, including trade and financial globalisation; and in individual economies, such as the decline in trade union power in the US and the opening of the South African economy to international trade. Monetary policy itself has shifted to a far greater focus on inflation. Clements and Hendry (1998, 2002) have highlighted the role of structural breaks in accounting for forecasting failures. As the 2008 experience graphically demonstrated, energy and food price shocks can be large and difficult to predict. Indeed, the speed of price changes tends to increase with big shocks. Most forecasting models used by central banks therefore put a large weight on recent inflation. This tracks inflation quite well, *except at turning points*, because the models miss key underlying long-run influences. Yet, it is at the turning points that good models are crucial.

What are the characteristics of a 'good model'? We argue that models with good predictability at turning points have some particular features. Instead of modelling inflation only or mainly in terms of *differences*, they include long-run relationships between the economic variables, especially relative prices. They use more richly specified models than, for instance, vector autoregressive (VAR) models with their degrees of freedom problems. They take account of structural breaks. They use longer lags to allow time for relationships to feed through than is common, say, in VAR models. They test for asymmetries and non-linearities.

We have used models of this type for our work on inflation in South Africa, and, more recently, in the US. Our US work has had particular policy

relevance in the global economic environment of 2008 and 2009 (e.g. Aron and Muellbauer, 2008a, 2008b). Our results in October 2008 predicted that we were on the cusp of the most significant turning point for US (but not South African) inflation in the past 20 years, so that many of the standard models would go badly wrong. The economics were straightforward. With global output probably falling faster in the fourth quarter of 2008 than at any rate since the war, large excess capacity would be expected to develop, while commodity prices fell. Some still believed that emerging markets would provide a stabilising influence on the world economy, but we suggested that the opposite was likely. Countries such as China are highly geared to exports and, above all, investment, which in China exceeds consumer spending. Apart from infrastructure, investment in health care and education, investment is geared to growth. So if growth fell more sharply than the reduction from 11 per cent to 9,3 per cent for 2009 predicted by the October International Monetary Fund (IMF) *World Economic Outlook*, the amplification on the fall in growth of a sharp fall in investment was likely to be considerable. As over-capacity developed, investment in goods production would fall even further, with serious implications for gross domestic product (GDP). It seemed unlikely that the Chinese government could act swiftly enough to boost domestic consumption to compensate. Hence the demand for commodities, which has been driven by emerging-market growth, would fall sharply. Eventually, however, lower commodity prices and lower inflation act like a large tax cut for households and will allow global interest rates to fall further and contribute to the stabilisation of economic activity in those countries not heavily dependent on primary commodity exports.

South Africa is caught in the cross-fire between two major trends: (1) global disinflation and (2) the collapse of the non-gold commodities super cycle. By early 2009, most metal prices and agricultural export prices had already fallen sharply. Gold prices remained high, reflecting the metal's multiple roles of inflation hedge, important industrial material and a 'safe haven' when other assets are perceived as risky. However, eventually, if policy-makers succeed in stabilising the global banking system, the gold price is likely to succumb to recession and low inflation, and this remaining support for the rand would be reduced.

Our research on new forecasting models for the US and South African inflation is closely relevant to the above issues (Aron and Muellbauer, 2008b, 2008c). Our monthly US inflation models for the US consumer price index (defined using the personal consumption expenditure deflator) build in a wide range of factors, including oil prices; producer prices; unit labour costs; import prices; prices in other countries and the

exchange rate; house prices; trade union density; and the unemployment rate. We have estimated similar inflation models for the three underlying components of the consumer expenditure deflator: (1) durable goods, (2) non-durable goods and (3) services. The models have been tested out of sample on monthly data from 2000 to the present, and they surpass by large margins the naïve models widely seen to be hard to beat (e.g. see Stock and Watson, 2003). For South Africa, our quarterly inflation models in the same 'genre', both for the total consumer price index excluding interest mortgage cost for metropolitan and other urban areas (CPIX) and for its ten sub-components, also outperform naïve models.[1]

A key element in these models is the *long-run* adjustment in consumer prices to costs and other prices. For instance, the US models suggest a long-run solution for US consumer prices as a function of unit labour costs, US house prices and foreign prices converted into dollars. Unit labour costs in the US have a weight of 50 per cent and are thus central to the model; they have remained low despite higher goods price inflation. House prices have a powerful effect in the model, entering with a long lag. Their importance lies in the role of rents in the CPI, but they may also reflect other macroeconomic influences. Viewed in October 2008, house price falls had offset some of the recent inflation from higher oil and food prices, and our results suggested that lower and still-falling house prices would be a significant deflationary force. Declining foreign inflation and recent dollar appreciation suggested little prospect of imported inflation. Since oil and food prices had fallen sharply, with further to fall, while unemployment was escalating, our models suggested that US consumer price inflation must *fall at record rates* for the 6–12 months measured from the final quarter of 2008. Our models of the underlying components, durable and non-durable goods and services inflation, further reinforced this view.[2]

In Section 2 we discuss our research on modelling producer price inflation in South Africa (Aron and Muellbauer, 2007a, 2009a), and its extension to forecasting producer price inflation at horizons of one, two and four quarters with a similar methodology to that in our US paper. At all horizons, the models incorporate unit labour costs, the output gap, import prices, the real exchange rate, a measure of trade openness and a monetary policy indicator based on the interest rate differential between South Africa and the US. The real exchange rate by definition incorporates foreign prices as well as the nominal exchange rate. While dollar oil prices and global inflation decline, the exchange-rate depreciation will be inflationary, though pass-through of the depreciation into producer prices may be incomplete. It will likely be substantially offset by a sharp domestic slowdown, with a declining output gap, and a wide interest rate differential, as interest rates in South Africa will have to remain relatively high for a time relative to the US and most industrial countries.

Section 3 summarises our recent paper on forecasting CPIX in South Africa. Recently, there has been renewed interest, especially on the part of central banks, in the potential for greater accuracy from forecasting the sub-components of the overall CPI and aggregating these forecasts, as against forecasting the aggregate itself. We compare this approach with single-equation forecasting models for aggregate CPIX.

One of the components that will become even more important is housing, with the introduction in January, 2009 by Statistics South Africa (Stats SA) of a new CPI measure, where owner-occupied housing is measured by imputed rents. Section 4 discusses these issues. We have long called for such a change, following the US, Australia and other countries, since using mortgage rates to proxy housing costs was conceptually flawed and damaging for policy (Aron and Muellbauer, 2004, 2005, 2007b, 2009b). Imputed rents will have to follow market rents, which then become much more influential for inflation. Given their importance, good-quality data will be important. To understand the likely future behaviour of the rent component, building good models of its past behaviour would be advantageous. Unfortunately, Stats SA has no data on rents before 1997, and this is too short a period for robust modelling, while data quality for some of the period is not all it could be. However, we do have data on the overall cost of housing excluding mortgage interest payments and we discuss some of our findings for this. The coming decline in real house prices in South Africa is likely eventually to have a larger influence on the new CPI than it would have had on the old. We refer to the US experience of switching to the new CPI in 1983 to illustrate the dangers of making such a switch when interest rates are far from being in a neutral position. Unfortunately, the switch in South Africa has occurred close to the peak of the interest rate cycle, and will lead to the overstatement of the CPI inflation rate.

Section 5 concludes with a brief discussion of recent criticisms of inflation targeting.

2. Modelling and forecasting wholesale prices in an open economy

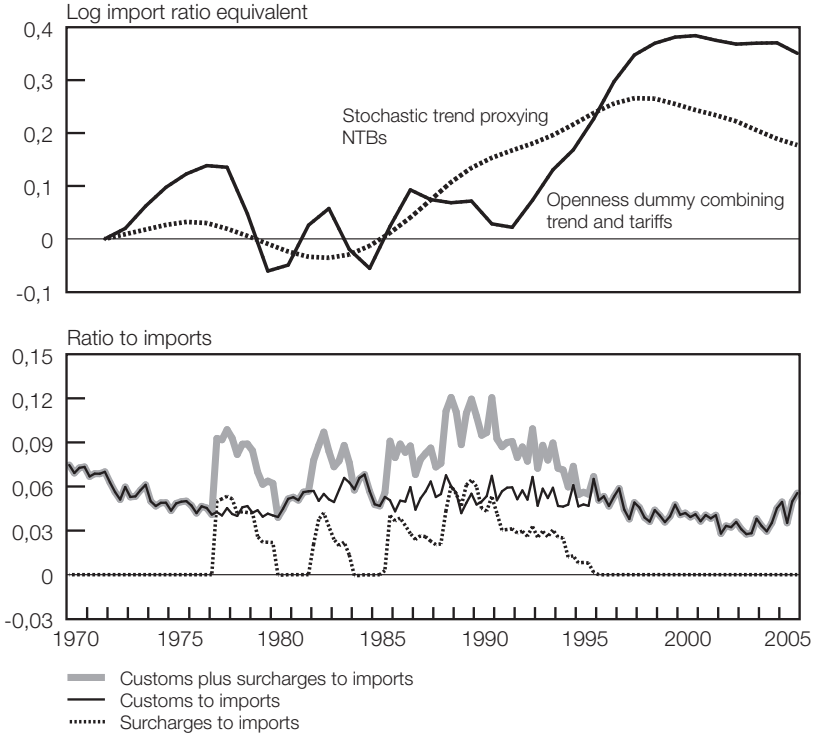
In the 1990s, South Africa became globally more integrated after years of isolation. Our recent work argues that accounting for changing trade openness plays a crucial role in obtaining stable and well-fitting equations for producer price inflation over longer samples (Aron and Muellbauer, 2007a, 2009a). In this section we explain how we measure openness, and discuss the estimation results, including those for an improved and more robust version of the South African Reserve Bank's own producer

price inflation equation. We then demonstrate similar findings in a forecasting context for the redefined producer price index now produced by Stats SA.

Evolving trade liberalisation represents a structural break, the omission of which can bias the determinants of inflation and output. Long time series measures of openness should improve the modelling and forecasting of output and inflation. Aron and Muellbauer (2007a) offer an innovative technique to measure evolving trade openness and provide evidence for the role of openness in explaining inflation. Our technique measures openness encompassing both observable trade policy (tariffs and surcharges) and unobservable trade openness (quotas and other non-tariff barriers), capturing the latter by a smooth non-linear stochastic trend[3] in a model for the share of manufactured imports in home demand for manufactured goods, controlling for the business cycle and exchange rate. The measure is constructed as a weighted combination of known trade policy and the stochastic trend, with weights from the regression coefficients in the model. In relation to South Africa, the shape of the trend is likely to reflect such factors as the lifting of capital controls and unification of dual exchange rates in the 1990s (as often used in composite measures of openness), and the lifting of externally imposed trade sanctions. It is possible that this measure also captures changing institutional aspects of the effectiveness of South African competition policy: limited competition is a factor behind the mark-up on costs charged by South African manufacturers emphasised by Fedderke et al. (2007), see also the overview discussion in Fedderke (2009).[4] The measure is shown in Figure 1, and correlates with known institutional changes in openness. Our survey demonstrates that the measure overcomes many of the shortcomings of existing measures.

The evidence for South Africa in Aron and Muellbauer (2007a) suggests that increased openness significantly reduced inflation in the 1990s. The non-tariff barriers proxy and tariff rates (excluding temporary surcharges) have a powerful effect on the mark-up charged by manufacturers in the long run. This results in a stable equation explaining the fluctuations in producer prices charged by manufacturers in South Africa from 1979 to 2005, a period of major structural changes. Paradoxically, given observed price stickiness, the negative effect of increased openness on labour and import costs probably *raised* the observed mark-up in the short run. Crude indicators of trade openness do less well in explaining the behaviour of producer prices, though the *constant price* version of exports plus imports relative to GDP is the best of them and has the merit of simplicity and ease for updating.

Figure 1: Openness measure and stochastic trend, plus the tariff ratios for South Africa



Sources: South African Reserve Bank *Quarterly Bulletin,* and Aron and Muellbauer (2007a)

We (Aron and Muellbauer, 2009a) further demonstrate how the producer price inflation equation in the South African Reserve Bank core model can be improved by taking account of greater openness, using *either* our innovative time-series openness measures or a more conventional measure, defined by exports plus imports divided by GDP, all measured in *constant* prices. The strong influence on producer price inflation of the real exchange rate and the interest rate differential, found in our earlier work, is confirmed. This makes explicit the foreign-exchange channel of monetary transmission on inflation, which is important in open economies. The (asymmetric) short-term role of food price inflation in the South African inflation process is also confirmed, and is relevant given record rises in world food prices in 2008. The result is a model for producer price inflation with a greatly improved fit and greater stability over longer samples, and a role for the *level* of the output gap rather than simply a short-run effect, as in the South African Reserve Bank's model. This helps mitigate

the arguments regarding the apparent unconcern of inflation-targeting policy for the level of economic activity: the important role for the output gap means inflation targeting automatically tends to stabilise output. Finally, our improvements to the South African Reserve Bank's producer price inflation model are easy to implement: essentially, we add five new regressors (including openness) to this model and relax a restriction on the short-term dynamics.

Further evidence in favour of this extended model for producer price inflation comes from a cointegration analysis (see Johansen,1988; Johansen and Juselius, 1990). We consider a set of five endogenous I(1) variables: (1) log producer price index, (2) log import prices, (3) log unit labour costs, (4) log real exchange rate and (5) the interest rate spread.[5] We treat the openness indicator like an exogenous trend and together with a step dummy, DUM2000, for the influence of inflation targeting, it is treated as part of the cointegration space. The homogeneity restrictions suggesting there is no money illusion in the long run are accepted, but we do not impose short-run homogeneity.[6] There are four cointegrating vectors, of which one can be interpreted as a long-run solution for the log producer price index. Only this vector is relevant for the inflation dynamics and corresponds quite well with the single-equation model for producer price inflation (see Aron and Muellbauer, 2009a).

Finally, we model current producer price inflation, and forecast producer price inflation one, two and four quarters ahead, using similar models to the above, for the *new* definition of the producer price index, as published in the South African Reserve Bank *Quarterly Bulletin* in June, 2008.[7] The variables are defined in Table 1 and results are presented in Table 2. All variables are I(1), save the output gap and the asymmetric terms.[8] Autometrics (Doornik, 2009) was used to reduce a general specification to parsimonious models. The general specification includes in the long-run solution for the log producer price index, equilibrium correction terms defined using import prices, unit labour costs, oil prices measured in rand, and producer prices for food. These are all defined by the log ratio relative to the producer price index. The long-run solution also includes a conventional *constant price* trade volume-based measure of trade openness measured as a four-quarter moving average, the log real exchange rate, the output gap,[9] the log terms of trade and the interest rate differential with the US. A shift dummy, Dum2000, which is zero before 2000 and 1 from the first quarter of 2000, is included to reflect the impact of inflation targeting on inflation. The dynamics include changes with lags up to three quarters in most variables, except in the asymmetric terms in oil and food prices. These enter only at the shortest lag, since we expect asymmetries to be relevant only over short periods.

Table 1: Variable definitions for parsimonious equations

Variable name	Variable definition	Mean	Standard deviation
log(PPI)	Log of new producer price index including exports and excluding imports	-0,665	0,716
log(ULC)	Unit labour costs measured as: log of National Accounts remuneration relative to real GDP	-1,52	0,814
log(ULC/PPI)	Long-run cost component: unit labour costs relative to PPI	-0,854	0,109
log(IMPP)	Import prices measured as: log of National Accounts total imports deflator	-0,739	0,718
log(IMPP/PPI)	Long-run cost component: import prices relative to PPI. Import prices measured as: log of National Accounts total imports deflator	-0,0743	0,104
log(TOT)	Log of the terms of trade	4,70	0,0747
log(REER)	Log of real effective exchange rate. A rise is appreciation	4,75	0,148
USSPREAD	Spread between the SA prime rate and US government Treasury Bill rate	0,108	0,0466
Log(FOODP)	Log of the raw price of food, from the agricultural food component of the new PPI	4,11	0,573
log(FOODP/PPI)	Long-run cost component: food prices relative to PPI	4,78	0,156
ASYMFOOD	Asymmetric effect of food price changes: Δlog(FOODP) if Δlog(FOODP)>0, and zero otherwise	0,0258	0,0311
log(POILR)	Log of the dollar Brent oil price converted into rands with the bilateral US$/ZAR exchange rate	4,28	0,749
log(POILR/PPI)	Long-run cost component: oil prices relative to PPI	4,95	0,397
ASYMOIL	Asymmetric effect of oil price changes: Δlog(POILR) if Δlog(POILR)>0, and zero otherwise	0,0657	0,0843
OUTGAP	The output gap measured as: log real GDP adjusted with a Hodrick Prescott filter (lambda = 1600) for potential GDP	0,107	1,67
MA4TRVOL	Conventional trade policy measure in real terms: ratio of real exports plus real imports to real GDP, 4-quarter moving average	32,0	7,71
DUM2000	Step dummy, 0 up to 1999 quarter 4, 1 from 2000 quarter 1		

Source: All variables from the *Quarterly Bulletin*, South African Reserve Bank, except the US Treasury bill and South African prime rates (from International Financial Statistics, International Monetary Fund). Mean and standard deviation measured over the sample, 1980Q1–2008Q2

This kind of reduced form inflation model captures inflation expectations indirectly, though some of the regressors may be more closely linked to expectations than others. For example, the inflation-targeting dummy probably has mainly an expectations interpretation. The interest rate differential probably acts, in part, on expectations of the exchange rate and hence inflation. Aron, Muellbauer and Smit (2003) confirm that it has a significant effect on the exchange rate.

The version of Autometrics used includes an outlier correction.[10] This searches for residuals approximately three or more times as large as the equation standard error and automatically inserts an impulse dummy for such residuals. In a forecasting context, very big shocks to oil prices, food prices and the exchange rate will typically cause large forecast errors. Controlling for the worst of these allows the systematic parts of the model, which track the transmission lags of shocks into producer prices, to be more accurately estimated. The resulting equation standard errors greatly understate forecast accuracy in a real-time setting since such large shocks can occur at any time.[11] Indeed, some of the largest shocks in the post-war period occurred to oil and food prices in 2008, and may yet occur in the exchange rate.

The results reported in Table 2 for the new definition of the producer price index are reassuring for the robustness of our earlier research, which had employed the previous measure of the producer price index. At all horizons, the unit labour cost and import price elements of the equilibrium correction term are strongly significant, with the latter having about half the weight of unit labour costs at all horizons. This is so, despite the fact that import prices are no longer directly included in the producer price index, which is based on prices of domestically produced goods, including exports. One difference from models for the old definition is that the log terms of trade are now relevant at all horizons. Since export prices are currently in the producer price index, log terms of trade defined as export prices/import prices should clearly enter the model with a positive coefficient and this is confirmed. The trade openness indicator, the output gap and the interest rate spread are also significant at all horizons.[12] The real exchange rate is typically insignificant – made redundant by import prices, oil prices and the terms of trade, which seem to capture the joint effects of the exchange rate and foreign prices.[13]

In the forecasting models, but not the model for the current quarter's rate of producer price inflation, the equilibrium correction term in rand oil prices is strongly significant. The dates at which large outliers occur are unsurprising. They reflect the large exchange rate and food[14] price shocks of late 2001, and the food and oil price shocks of 2008. The inflation-targeting dummy is significant at forecasting horizons of one, two and four quarters, and could be interpreted as a measure of the success of

Table 2: Quarterly producer price index estimation and multi-step producer price index forecast equations for the new measure of producer price index in South Africa

1			2			3			4		
Modelling: Δlog (PPI) 31 Mar 1980 – 30 Jun 2008			Forecasting: Δlog (PPI)(+1) 31 Mar 1980 – 31 Mar 2008			Forecasting: Δlog (PPI)(+2) 31 Mar 1980 – 31 Dec 2007			Forecasting: Δlog (PPI)(+4) 31 Mar 1980 – 30 Jun 2007		
	Coefficient	*t*-value		Coefficient	*t*-value		Coefficient	*t*-HACSE		Coefficient	*t*-HACSE
Dynamic terms and seasonals:											
Δlog (PPI)(-2)	0,156	2,3	Δlog (PPI)	0,181	2,09	Δlog (PPI)	0,188	2,23	Δlog (PPI)	-0,232	-2,63
Δlog (PPI)(-3)	0,212	3,16	Δlog (PPI)(-2)	0,249	3,02	Δlog(IMPP)	-0,0306	-1,42	Q1	0,00343	1,78
Q1	0,00600	3,99	Δlog(POILR(-1)	-0,0122	-2,16	Δlog(POILR)	-0,0149	-2,84	Δlog(ULC)	-0,111	-2,04
Q2	0,00307	2,12				Δlog(TOT)	-0,0357	-2,19	Δlog(POILR(-1)	-0,0130	-2,05
Δlog(IMPP)	0,0993	6,36									
Δlog(IMPP)(-1)	0,0629	3,66									
Δlog(FOODP)	0,0862	5,21									
ASYMOIL	0,0252	3,38									
Δlog(TOT)	0,0293	2,14									
Outliers:											
I:2008-06-30	0,0532	7	I:2001-12-31	0,0378	4,65	I:2001-09-30	0,0389	17,1	I:2007-06-30	0,0628	16,1
			I:2008-03-31	0,0558	6,24	I:2007-12-31	0,0555	12,9			
Long-run terms and dummies:											
Constant	-0,129	-2,48	Constant	-0,171	-2,63	Constant	-0,190	-2,3	Constant	-0,132	-1,79
DUM2000	-0,00467	-1,41	DUM2000	-0,0136	-3,42	DUM2000	-0,0152	-4,48	DUM2000	-0,0185	-4,27
MA4TRVOL(-4)	-0,00064	-4,36	MA4TRVOL(-4)	-0,00075	-3,75	MA4TRVOL(-4)	-0,00098	-5,21	MA4TRVOL(-4)	-0,00163	-5,9
USSPREAD(-1)	-0,0405	-2,02	USSPREAD(-1)	-0,0675	-2,72	USSPREAD(-1)	-0,0748	-2,38	USSPREAD(-1)	-0,1058	-3,19
OUTGAP(-1)	0,00158	3,23	OUTGAP	0,00273	4,17	OUTGAP	0,00230	4,84	OUTGAP	0,00317	4,63
log(TOT)(-1)	0,0458	3,87	log(TOT)	0,0587	3,99	log (TOT)	0,0634	4,19	log(TOT)	0,0637	4,8
log(IMPP/PPI)(-1)	0,0436	3,58	log(IMPP/PPI)	0,0528	3,55	log(IMPP/PPI)	0,0545	4,3	log(IMPP/PPI)	0,0796	4,66
log(ULC/PPI)(-1)	0,613	3,8	log(ULC/PPI)	0,109	4,81	log(ULC/PPI)	0,113	5,67	log(ULC/PPI)	0,146	4,86
			log(POILR/PPI)	0,00799	2,42	log(POILR/PPI)	0,0109	2,91	log(POILR/PPI)	0,0121	3,59
Diagnostics:											
Equation standard error	0,005939		0,007729			0,008378			0,00847		
Adjusted R^2	0,820		0,686			0,637			0,616359		
DW	1,93		2,09			2			1,65		
Chow (mid-sample)	p = 0,00		0,49			0,22			0,08		
Normality test	p = 0,47		0,35			0,13			0,003		
AR/MA1-test	p = 0,731		0,50			0,96			0,09		
AR/MA4-test	p = 0,024		0,15			0,10			0,27		
hetero test (Breusch)	p = 0,115		0,07			0,26			0,11		

the inflation-targeting regime, probably working through inflation expectations, as noted above. This supports our finding in Aron and Muellbauer (2007b, 2008d, 2009b) that the new policy framework became quickly embedded in interest rate expectations.

Individual equations are now discussed in more detail. Column 1 in Table 2 shows results for the current log change in the producer price index. This equation includes three potentially endogenous terms: the current log changes in import and food prices and an asymmetric term in rand oil prices (defined to be zero if the log change is negative, otherwise equal to the log change). The last term is consistent with the widespread view that oil price increases are passed on more quickly than decreases. Our previous work suggests that instrumenting these variables does reduce some of the coefficients slightly, but otherwise has a negligible impact on the results (Aron and Muellbauer, 2007a, 2009a). We have not tested this here, as our principal focus is the forecasting models. The inflation-targeting dummy has a negative, but insignificant coefficient in this specification, probably because much of the effect on inflation expectations is already reflected in the three potentially endogenous variables. The reported equation fails the mid-point Chow test, possibly because of the endogeneity bias. However, approximating an instrumented equation by excluding current import price inflation and the current change in the terms of trade yields a similar equation that passes the Chow test and has a significant inflation-targeting dummy.

The one outlier added to the model is for the second quarter of 2008. Despite the inclusion of contemporaneous oil, food and import prices, the model fails to capture the sharp rise in producer price inflation in that quarter. This may suggest a specification problem.[15] In this exercise, we have not included the non-linear lagged inflation terms found so relevant in our US consumer price inflation forecasting model. The latter was interpreted as a symptom of 'state-dependent' pricing in which, when cost inflation goes to high levels, the speed of price adjustment rises and inflation jumps further. This will be covered in a future investigation of this issue for South Africa.

Column 2 presents results for the one-quarter ahead forecasting horizon. All the key variables discussed above appear. The lagged log change in rand oil prices appears with a seemingly anomalous negative coefficient, but it is only marginally significant. Omitting it makes little difference to the results. The outliers are dated 2001Q4 and 2008Q1, but given that the dependent variable is one quarter ahead, this means they refer to producer price inflation shocks in the first quarter of 2002 and the second quarter of 2008.

Column 3 presents very similar results for the two-quarter forecasting horizon. The outliers capture the same shocks as in column 2. The

negative coefficients on the log change in oil prices can be interpreted to mean the equilibrium correction term can be lagged one quarter. The negative coefficient on the log change in import prices and the terms of trade suggest that a two-quarter moving average of the level of log import prices and the terms of trade would be a more parsimonious representation of these long-run effects.

Column 4 shows that for the four-quarter ahead forecasting horizon, very similar drivers are selected. At this horizon, the effect of the inflation-targeting dummy is estimated at minus 0,018. This could be interpreted as a 1,8 per cent benefit in terms of annual inflation of introducing the new monetary policy framework. However, several other variables are included in the model, such as the interest rate spread, which could themselves have been affected by the policy shift. Nevertheless, it is an encouraging result.

One of the remarkable features of the four-quarter-ahead model is that the equation standard error is only a little above that of the two-quarter-ahead model, despite the greater uncertainty that should be associated with the longer horizon. This may also indicate effectiveness of the new monetary policy regime, in that over longer horizons, successful policy should bring inflation back on track and so reduce the private sector's uncertainty about future inflation. The South African Reserve Bank's fan charts for the inflation outlook should reflect this feature at longer horizons.

One implication of these models is that forecasts made recently on second quarter of 2008 data will need radical revision when the forecasts based on fourth quarter of 2008 data are made. The fall in oil prices, the decline in the output gap and the rise in the US spread are all deflationary. It looks as though the fall in the terms of trade due to the collapse of South Africa's commodity export prices will be larger than the corresponding decline in the rand exchange rate, and is likely to be deflationary for producer prices. So the main source of inflation in 2009 could be from import prices, if the decline in underlying foreign currency prices of imports is more than offset by the fall in the rand. For rand oil prices, the opposite is true: the decline in dollar oil prices exceeds the fall in the rand. One can make a case that for 2009 the overall consequences for producer prices are on the deflationary side, though obviously South Africa will not experience the complete collapse of inflation that is already visible in the US (Aron and Muellbauer, 2008a), to be followed by Europe.

We have treated structural breaks in this reduced form model in two ways: (1) by including a dummy for the inflation-targeting period and (2) by including a continuous but slowly moving openness variable, which we treat like a dummy. The effects from structural change may, however, be more complex than we represent here, that is, not just inducing

changes in the intercept coefficient. We might expect to find varying parameters if we were to test for interactions between say the dummies and particular variables, such as the exchange rate (e.g. see Aron and Muellbauer, 2002). This deserves further exploration in the current context. Plots of recursive betas for the models reported in Table 2 (not shown here) are fairly reassuring on parameter stability. Certainly, parameter stability is far superior than for models excluding the openness indicator and the inflation-targeting dummy.

3. Modelling and forecasting CPIX and the components of CPIX

We have also worked on modelling and forecasting the consumer price index, using models embodying the same principles we emphasised above: (1) the importance of including long-run relationships between the economic variables, especially relative prices, rather than casting the inflation models only or mainly in terms of *differences*; (2) using far more richly specified models than is common with many techniques, especially those constrained by degrees of freedom problems; (3) enhancing the robustness of models by taking account of structural breaks (e.g. greater openness), and testing for potentially changing coefficients with structural change; (4) using longer lags to allow time for relationships to feed through, than is common say in VAR models; and (5) testing for asymmetries and non-linearities, though the latter issues remain to be explored further in the current version of the work.

Our recent paper (Aron and Muellbauer, 2008b) on modelling and forecasting the CPIX and the ten underlying sub-components applies these principles in both aggregate and sectoral models. Apart from shedding light on the underlying sectoral sources of inflation, potentially useful to monetary policy, our aim was to see if we could *outperform* an aggregate forecasting equation for CPIX (the *direct* forecast) by a weighted sum of the individual forecasts for each of the underlying ten components in the CPIX basket, for example, food, housing, clothing and transport goods (the *indirect* forecast). There has been renewed interest, mainly by central banks, in investigating whether there are gains to forecast accuracy in aggregating weighted forecasts of the sub-component price indices, as against forecasting the aggregate itself.[16] This makes sense because inflation is a far from homogeneous phenomenon. Disaggregating the price index into its sub-components potentially can increase information in the forecasting process. Different information sets tend to apply to different sectors, for example, technological innovation, taxation and the extent of competition may vary, and trends in sub-components may differ for structural reasons. If the econometric specifications can be allowed to vary across disaggregated components, and the dynamic properties of individual components alter depending on the sector, the

result may be better than forcing the same response across all sectors in an aggregate model. The sectoral approach is also useful for examining the impact of changes in weights, both for regular reweighting and for the kind of change in CPI planned for January 2009.

In our paper, four-quarter-ahead forecasting models for CPIX and the ten main sub-components of CPIX were developed, combining equilibrium correction, trade openness and split trends[17] to handle structural shifts. These models permit the adjustment of prices to trends in relative prices and in prices relative to input costs to be part of the inflation process. Plausible restrictions were applied to overcome the 'curse of dimensionality' in order to select parsimonious models. We selected models for 1979–2003 and recursively forecast to the end of 2007, to compare the performance of models corresponding to differing information sets. The sectoral four-quarter ahead forecasts from the sub-component equations were aggregated using actual sub-component weights from the CPIX basket. The 'indirect' forecast thus obtained was then compared with various forecasts of the aggregate CPIX index.

The exercise involved a considerable amount of data construction and manipulation. For instance, as the CPIX data were only policy-relevant from 2000, and only constructed by Stats SA back to 1997, we used our own consistent construction of monthly CPIX data back to 1970 from Aron and Muellbauer (2004). This paper, in the absence of an official handbook and drawing on Haglund (2000), has contributed to greater clarity on the methods used by Stats SA on constructing the CPI.[18] We also constructed HX, the housing component less the mortgage interest cost, back to the start of the sample, for both the "metropolitan" component before 1997 and the "metropolitan and urban" component from 1997, using the methods of Aron and Muellbauer (2004) and appropriate weights, and splicing the two in January 1997.[19]

To summarise the results, we find that increasing trade openness has substantially reduced the inflation rate in South Africa. An aggregate CPIX equation incorporating only *changes* in the wholesale price index, unit labour costs, the real exchange rate, import prices, terms of trade, oil prices, the output gap and trade balance to GDP ratio, and the level of trade openness achieves a 28 per cent reduction in the root mean squared forecast error (RMSFE) relative to the best of the naïve models based only on lags in CPIX inflation rates. Applying the same methods to each of the inflation components, and weighting the forecasts using the CPIX weight to obtain an 'indirect' forecast for CPIX, brings a further gain of 4 per cent relative to the naïve model benchmark, see Stock and Watson (2003) on the use of these hard-to-beat benchmarks. In a further extension of the data to bring in equilibrium correction components in relative prices, and the level of the output gap, trade balance, terms of trade, the real exchange

rate, and split trends, forecasts from the aggregate CPIX equation have an RMSFE, 32,5 per cent lower than the best of the naïve models. Applying these extensions to the data set for the individual CPIX components and, in addition, bringing in specific sectoral information, such as house prices in the housing cost equation and the wholesale price index for food manufacturing in the food equation, we can obtain a further 8 per cent reduction in RMSFE relative to the naïve benchmark.

Moreover, using *naïve* models based only on lagged CPIX inflation rates, the weighted 'indirect' forecast does not improve on the 'direct' forecast for aggregate CPIX inflation. However, in the model incorporating producer price inflation, the real exchange rate and so forth, but without equilibrium correction, the weighted 'indirect' forecast improves on 'direct' forecasts bringing in similar data. In the models with equilibrium correction, the weighted 'indirect' forecast further outperforms the 'direct' forecast using similar data.

At the aggregate CPIX level, we find long lags in strongly significant equilibrium correction terms with respect to unit labour costs and to oil prices, and in the terms of trade and the output gap. Indeed, we more generally find that far longer lags are relevant than conventionally considered in VAR modelling. These lags have been brought to light by our technique of using parsimonious representations of longer lags (such as four-quarter moving averages) to overcome the 'curse of dimensionality'. Instead of taking nine parameters to represent a maximum lag of nine quarters, we use four. This saving makes it possible to consider a richer menu of driving variables than conventionally used in VAR studies. The further parsimony from use of automatic model selection helps to overcome an important source of forecast error, namely parameter estimation uncertainty, which is an aspect of the 'curse of dimensionality'.[20]

Thus, as well as serving as a prelude to designing practical forecasting models for overall inflation, these models cast important light on the complex forces acting on the relative prices and inflation rates of the different goods and services, explaining higher inflation rates in some sectors and the different persistence of shocks in the different sectors. We concentrated on forecasting four quarters ahead. But exactly the same exercise could be carried out at shorter and less challenging horizons one and two quarters ahead. This has further practical policy connotations. Corresponding to each horizon, an estimate of the RMSFE could be obtained for the selected forecasting period. These could be used to calibrate the fan chart for inflation forecasts over different horizons using these methods. To extend this work, the inclusion of sectoral information, such as an explicit treatment of tax policy, regulatory information and announced administered price rises, should further enhance these forecasting methods.

4. Modelling housing costs and the rent component

Our inflation forecasting work for CPIX and its components is now particularly germane, as South African Reserve Bank economists and other South African economists need to assess the implications of the introduction by Stats SA of the new CPI measure in January 2009, in which imputed rent is adopted as the measure of homeowners' housing costs. The adoption of the new CPI as the targeted inflation rate needs careful consideration for two reasons. The first is quality assurance. The US Bureau of Labor Statistics (BLS) ran an experimental version of the new CPI where homeowners' costs were measured by equivalent rents, from 1980 to 1982, before making the switch in January 1983. Careful research went into the sampling frame and the imputation methods used to estimate for owner-occupied houses of various types, what the rent would have been if such a house had been let on the rental market. Since the composition of the stocks of rental and owner-occupied housing is different, it is unlikely that imputed rents will necessarily follow an aggregate rent index very closely, though it is likely to be subject to the same influences. The second is to avoid the mistake made in the US in making the switch at a very far from neutral point in the cycle in 1983. The pre-1983 CPI was based on an investment cost approach to measuring housing costs of homeowners. Apart from repairs, maintenance and insurance, both the mortgage interest rate and the level of US house prices entered the pre-1983 CPI-U for all urban households (see BLS, 2007, for a recent summary of the methodology).

In a 1985 study (BLS, 1985) the BLS showed that under the new measure of homeowners' costs, the index would have increased by 165 per cent from 1967 to January 1983. By contrast, the official CPI-U climbed by almost 188 per cent during the 16-year period, as both house prices and mortgage interest rates rose over the period. When interest rates subsequently fell, the new rental equivalence measure of CPI-U fell far less than the old measure would have done. By linking the two in January 1983, inflation was overstated, and pensions and social security payments rose more than intended. It is likely that interest rates were kept higher than necessary to bring down measured inflation.

Research on modelling US rents suggests that, in the long run, rents are driven by mortgage interest rates, property taxes, consumer prices more generally and house prices.[21] However, the speed of adjustment is remarkably slow, which is why imputed rents only responded moderately to the rises in US mortgage rates from 1979 to 1982, and moderately to their subsequent decline.

We originally intended to run models for past rents for South Africa in order to understand the role of house prices, interest rates and other costs in

driving rents, since imputed rents will be based on the rent data. We expected the rent measurement error uncovered in 2003 to contaminate the data and intended to test the robustness of equations to the omission of the years most affected by poor data. However, the data series on the disaggregated housing component were so short as to make this exercise pointless: the monthly *disaggregated* indices go back only to 1997.[22] We have previously referred critically to the loss of pre-1997 information on price indices (Aron and Muellbauer, 2004: 907). For modellers, the loss of pre-1997 information continues to be a big disappointment.

In consequence, we, instead, briefly examine the drivers in the equation for our housing component excluding the mortgage interest rate, HX, referred to in section 3. HX comprises several weighted sub-components, including rents, interest rates, insurance, repairs and maintenance, rates and water.[23] We expect some of the same variables to influence the rental component. In the present paper, we have taken the modelling of HX further, using the following economic considerations. If one thinks about the cash-flow costs of a landlord, major elements are the price of a house and the mortgage cost of servicing a loan. For a given loan-to-value ratio, the log cost to the landlord is determined, on average, by the log nominal mortgage rate plus the log of the house price index. However, landlords are also interested in the capital appreciation relative to the interest cost of borrowing and are willing to accept a lower rent in exchange for capital appreciation. One can also think of this return as the negative of what is often called 'user cost', defined as the interest rate minus the rate of capital appreciation. The landlord also has other outgoings related to prices of inputs and perhaps the general cost of living.

Using the equilibrium correction framework outlined in section 2, we have modelled log HX using a rich set of variables and lags. We used Autometrics to find a parsimonious equation. In the long-run solution, from a four-quarter-ahead equation:

log HX = 0.07*(log prime + log HP) + 0.22*log CPIX + 0.71*log IMPP
+ 0.46* USERCOST -1.0*RCURBAL + 0.018*trade openness
– 0.0034*(SPLIT TREND 1985)

The quarterly equation also includes short-term dynamics and was fitted for 1979 to 2007. Prime is used as a proxy for the mortgage rate; HP is the house price index for medium-sized houses; IMPP captures import prices (measured as the log of National Accounts total imports deflator), which probably has some bearing on forecasting other elements of housing costs, one year ahead. Its coefficient is lower in other specifications and not too much weight should be placed on this particular estimate. USERCOST is defined as $prime_t$ - (log HP_t - log HP_{t-4}). In other words, the user cost is the interest rate minus the rate of appreciation of house

prices, using recent appreciation for expected appreciation. RCURBAL is the ratio of the current-account surplus to GDP. It has a dual role, both as an excess demand indicator, and for its implications for the exchange rate and hence next year's inflation, and its negative sign is consistent with this. Trade openness appears with a positive coefficient, which might appear paradoxical, given the anti-inflationary role of trade openness. However, the long-run solution includes import prices, which have fallen a great deal relative to prices of non-tradeables. Hence the openness indicator may be needed to stabilise the long-run solution.[24] The general specification included split trends beginning in 1985 and 1995 to capture potential long-run shifts due, for example, to demography, taxation or political changes. Only the former split trend was found significant.

Given the heterogeneous elements included in HX – it is not itself a rent index, and given serious issues of data quality, we do not want to over-interpret these particular findings above. The estimated role of interest rates and house prices is, however, interesting for policy. The dynamics suggest that log HX four quarters ahead responds positively to interest rates two and more quarters ago, giving a total lag of six or more quarters. The lagged positive reaction to house price rises is partly offset by the temporary reduction in user costs with house price appreciation. This may help explain why rents tend not to soar in house price booms, nor necessarily decline in downturns. House prices themselves are, of course, sensitive to interest rates, declining with higher rates.

The bottom line is that our evidence suggests a muted and quite delayed response of housing costs to interest rates. Unlike the current headline CPI, which includes mortgage interest rates (but illogically does not include house prices), the new CPI would give scope for monetary policy to lower inflation before any direct feed-through from higher mortgage costs into rents occurred.

The National Treasury announced in October 2008 that from January 2009 the inflation target would be based on the new CPI including homeowners' equivalent rent. Switching at such an extreme point in the cycle risks building the kinds of biases that occurred in the US, on account of the 1983 switch. Our earlier discussion suggested that it would be unlikely for South Africa to be able to participate fully in the decline in global interest rates by January 2009, as inflation will still be high because of the fall in the rand.[25] Later in 2009, as the economy follows the rest of the world into recession, and global inflation is sharply lower, further cuts are bound to follow. It is perfectly plausible that by January 2010, mortgage bond rates could be 11 per cent, compared with 15 per cent in January 2009, a proportionate fall of 27 per cent. The old CPI, with a weight of around 10 per cent on the mortgage bond rate, would therefore have fallen by almost three per cent, given other prices. Moreover, there is a risk,

highlighted by our research on non-mortgage housing costs summarised above, that rents in 2009 might still be catching up with the inflation and rate rises of 2007–08. It is therefore *possible* that, by January 2010, the new CPI will be measuring annual inflation as much as four percentage points higher than the old CPI would have done.

From January 2009, Stats SA will be measuring the 12-month inflation rate using data on owner equivalent rent going back to January 2008.[26] A longer-term retrospective, of the kind carried out by BLS (1985), on what inflation would have been had the new methodology been in place years earlier, is not possible. This is because the new methods of measuring rents were phased in gradually in 2006 and 2007 as Stats SA extended its new quarterly rental survey to all CPI collection areas (see Stats SA, 2008, 2009). The implied linking of the old and new CPI data in January 2008, will result in the overstatement of inflation in the period 2005–11. This is because the linked CPI would capture the rise in mortgage rates from 2005 to the end of 2007, as interest rates were embodied in the old CPI, but not their subsequent fall, since the new CPI does not include interest rates, but imputed rents. A better longer-term perspective on inflation in this period is likely to be offered by CPIX, which excludes mortgage interest rates altogether. Unfortunately, CPIX will no longer be published. Analysts would be well advised to use the consumer expenditure deflator from the National Accounts for a consistent measure of the consumer price level for 2005–11.

As a result of the switch in the definition of CPI, holders of CPI-linked indexed bonds are likely to make an unexpected gain of the order of four per cent in 2009, at considerable cost to taxpayers. To the extent that wages and other prices are linked to headline CPI, inflation in 2009 and interest rates will turn out to be higher as a result of the switch, at some cost to the economy.

5. Conclusions

Western central banks faced unprecedented challenges in 2007, and even more so in 2008 and 2009. Their actions have been forced to extend far beyond their conventional interest-setting remit. Many have had to co-operate with national treasuries in a way that compromises their independence and raises questions about the democratic accountability of unelected central bankers. Some have also faced heavy criticism for inadequate anticipation of events, for policy errors in earlier years and for inadequate regulation of the financial system – where central banks share such responsibility. Less-than-adequate econometric models used by many Western central banks, with little or no role for the credit channel and simplistic textbook views of the inflation process, have contributed to some of the lack of foresight now revealed. The research

discussed in this paper, with a more open-minded approach to learning from data, should help to clarify the international inflation context.

As the international financial crisis and the global recession have spread to emerging markets, serious challenges have developed for emerging-market central banks. Those countries where there have been credit-driven house price and consumption booms, with large current-account deficits and with commodity price dependence face unpleasant currency falls and stagflationary shocks. Monetary policy in South Africa has wisely been on a tightening course for some years, financial regulation has been relatively cautious (see Llewellyn, 2009, and a discussion of this paper by Dykes and Nel), debt denominated in foreign currency remains low and household indebtedness relative to income is substantially below levels in the UK, the US and other liberal credit market countries. Despite these positives, South Africa is not immune from these challenges. For South Africa, the inflation models we have discussed should prove helpful to the policy debate.

Inflation targeting has come in for increased criticism, see the Stiglitz (2008)–Mishkin (2008) debate, and the question of leaning against asset price 'bubbles' has received much re-examination. It is important to emphasise that fiscal policy, the design of the institutional and regulatory framework, and other political decisions have an important role to play in supporting central banks to maintain stability. Though the origins of the US crisis are multi-fold, the following contributed significantly: the US tax system, which gives unlimited tax relief on mortgage interest; the implicit guarantees on Fannie Mae and Freddie Mac, which disguised the true riskiness of mortgage-borrowing decisions to US households; and the government's drive to extend homeownership to low-income families, using private debt. With a slight question mark over the last of these, these problems have been avoided by South Africa. However, for the future, it is worth drawing the attention of politicians and the South African National Treasury to the merits of the stabilising property tax reforms discussed in Aron and Muellbauer (2005, 2007b, 2009b) to reduce the risk of future asset price inflation.

A significant issue for monetary policy in South Africa in 2009 and 2010 will be the change in the treatment of homeowners' housing costs introduced in January 2009, from the old mortgage interest cost basis to the new owners' equivalent rent basis. Unfortunately, this occurred virtually at the top of the interest rate cycle, as it did in the US in 1983. To the extent that wage negotiators and price setters pay attention to headline CPI, the rise in CPI caused by the rise in interest rates from 2005 to 2007 will not be offset by the prospective fall in rates in 2009, as rates no longer feature in the new index from January 2008. Instead, the imputed rental component of the new CPI may still be catching up in 2009 with the previous year's inflation and interest rate rises, thus biasing upwards the public's perception of

inflation since 2005 (see section 4). A useful check on possible biases, in our view, would be for the South African Reserve Bank to construct its own CPIX index (i.e., removing the owner-equivalent rent component) and to monitor deviations between this old targeted measure and the new targeted CPI measure.

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Notes

[1] For details on the naïve models, see Table 3 in Aron and Muellbauer (2008c). These models did not include structural breaks and are mainly, but not only, univariate.

[2] Between October 2008 and January 2009, record falls in US consumer prices suggest the US 12-month inflation rate could be negative early in 2009. It was essentially zero for December 2008.

[3] In a model that captures known influences on the import ratio, any unexplained variance (apart from white noise error) is then represented by the stochastic trend estimated using STAMP (Koopman et al., 2000).

[4] Fedderke et al. (2007) support our analysis, however, by showing that markups are lower in sectors with higher import and export penetration ratios. Fedderke (2009) also stresses the differential effect on firms of opening the economy, depending on their distance from the technology frontier, though the macro implications of this are unclear.

[5] This is an extended data set compared with Fedderke and Schaling (2005), who model the GDP deflator, and incorporate unit labour costs and the real exchange rate in the long-run solution, and also find a significant output gap effect, but do not include trade openness. Pretorius and Smal (1994) also find an important role for unit labour costs and the exchange rate.

[6] Long-run homogeneity implies that the sum of the coefficients in the equation on logs of levels of nominal variables is zero or, equivalently, that they all appear in log relative price form. Short-run homogeneity would imply that the sum of coefficients on quarterly log changes of nominal variables sums to zero.

[7] The new definition of the PPI correlates less well with the CPI, including as it does export prices (see Table 1, and for details, see the Stats SA website).

[8] The results of non-stationarity testing were given in Aron and Muellbauer (2009a, Table 2) for most of the variables over a slightly shorter period, using critical values from MacKinnon (1991).

[9] While the output gap is stationary, it is properly included in the long-run solution as a very persistent variable in the medium run. Our use of the HP filter to construct the gap resulted in little difference compared with more sophisticated methods, for example, in Aron et al. (2003).

[10] Autometrics is an objective and easily reproducible tool, not affected by the subjective choices of the modeller. Any other investigator with the same data and the same specification of the general unrestricted model (GUM), will then make the same model selection, given the chosen settings in Autometrics. This software examines a full set of general to simple reduction paths to select a parsimonious form of the GUM to satisfy a set of test criteria. The test criteria include tests for normality, heteroscedasticity, ARCH residuals, residual autocorrelation, parameter stability in the form of a Chow test, and the RESET test. There is also the option of automatically dummying out large outliers. In our context, the overlapping nature of the dependent variable means that residuals will be autocorrelated and so the corresponding tests, including portmanteau tests, are switched off. Further, outliers can easily arise, especially over 6- or 12-month horizons because of unpredictable changes in energy and other commodity prices. Heteroscedasticity could therefore be endemic. The corresponding tests are also switched off, but use heteroscedasticity and autocorrelation corrected (HAC) *t*-ratios and *F*-tests for model selection.

[11] The square root of the out-of-sample forecast errors for an extended sample, say the past five to ten years, is a guide to the uncertainty that surrounds inflation forecasts over different horizons, making it possible to construct a fan chart akin to those in the South African Reserve Bank *Monetary Policy Review*. The multi-step forecasting method, while different from the recursive forecasts from the system of estimated equations in the South African Reserve Bank model, as noted by our discussant Coen Pretorius, provides a useful benchmark for comparing forecast accuracy.

[12] It is possible to test for the relevance of the real spread, simply by including US producer price inflation on the right-hand side, given that lags of domestic producer price inflation are already included. The test supports the specification shown in Table 2.

[13] There are specifications where the real exchange rate is significant, but then import prices and the unit labour cost lose relevance. On *a priori* grounds, we prefer models with plausible unit labour cost effects. Autometrics has an option in which selected variables are required to be included in the parsimonious reduction from the general unrestricted model. This is a way of allowing priors to influence model selection. But the evidence can contradict the prior if the relevant variable has the wrong sign or is insignificant. Our priors for the relevance of the output gap; the equilibrium correction terms in unit labour costs; import prices and oil prices; the inflation-targeting dummy; and the interest rate spread are supported at all three forecasting horizons. In all specifications, we require the constant term to be included in the model.

[14] In the one-, two- and four-quarters ahead forecasting models, food prices do not appear directly. Evidently, food price shocks are transmitted so fast and food prices are so hard to forecast, that lagged food prices have little information content for forecasting producer price inflation.

[15] It was suggested by a discussant at the conference that measurement error may have affected producer price index data for the second quarter of 2008.

[16] The majority of studies applies to the euro area, and two to the US – none for the UK or other countries, including emerging-market countries, see Aron and Muellbauer (2008a) for a literature survey.

[17] In Aron, Muellbauer and Pretorius (2009c), we developed a stochastic estimation framework for components of the basket of consumer spending. Potential structural breaks were explored by modelling the four-quarter ahead price index components for 1979–2002 using smooth non-linear stochastic trends to help indicate such shifts, and estimating via the Kalman filter in the STAMP package (Koopman et al., 2000). The shapes of these trends then suggested the design of deterministic split trends for use in recursive forecasting models.

[18] In this paper and others we urged a shift to the imputed rent measure of homeowners' costs in the CPI measure. This has now occurred in January 2009, replacing the poorly based mortgage interest measure used up to now: see "Housing in the consumer price index", July, 2008, Stats SA website. See section 4.

[19] To create long time series of CPIX components, we used the available sub-component CPI data for "metropolitan and urban" households, and spliced it to the earlier CPI "metropolitan" components in January 1997 (all seasonally adjusted). Our constructed overall CPIX had to be seasonally adjusted, as it is based on Stats SA's seasonally unadjusted data. The unavoidable assumption to create historical data for the CPIX and its sub-components is that the price movements at the sub-component level do not differ greatly between the two types of survey.

[20] In practical forecasting work regular re-selection is advisable. In Aron and Muellbauer (2008b) on US monthly data we find that the absence of regular reselection handicaps forecast performance relative to simply retaining the general model.

[21] Unpublished mimeo by J Duca (Dallas Federal Reserve, US), J Muellbauer and A Murphy.

[22] Stats SA tells us that prior to 1997 the computer program did not store the detailed indices on a monthly basis. Only the published (aggregated) information was stored. In 1997 a new program was written which does store the information in this format.

[23] The rental categories: house, flat and townhouse rent comprise 40 per cent of the weight in HX (which excludes the mortgage interest rate) using 2000 weights for "metropolitan and urban" CPI. The bulk of the remainder is made up of insurance, maintenance and repairs, water, assessment rates, and sanitation.

[24] A conceivable alternative interpretation is that the positive coefficient on openness might be reflecting lower future expected inflation and hence interest rates, with a positive impact on house prices.

[25] Indeed, the first 0,5 percentage point cut in the repurchase (repo) rate occurred only in December 2008.

[26] Conventionally, CPI is not revised. The South African procedure of retrospective linkage thus differs from that of the US where methodology has altered; the

new CPI in the US has been linked from the date of introduction, not retrospectively. Obviously, anyone with a hand-calculator could splice later in 2008 than in January, since the old CPI continued to be published to the end of 2008.

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