South African real interest rates in comparative perspective: theory and evidence

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Real interest rates lie at the heart of the transmission mechanism of monetary policy. Although in the long run real interest rates are determined by real factors such as the propensity to save and the productivity of capital, monetary policy can impact on the real interest rate in the short to medium term. This paper surveys the theoretical and applied literature on real interest rates from a South African perspective, and compares South African real interest rates in an international and historical context. The nature of the linkages between South African and international real interest rates is also considered using a fractional integration approach. What emerges from the analysis is that, viewed historically, South Africa's real interest rates tended to broadly follow international trends. Although short-term real rates in South Africa have recently been high by historical standards and relative to some low-inflation countries, it is argued that this situation cannot be seen in isolation from the current monetary policy framework and the level of the inflation rate relative to the target. Current rates reflect to a certain extent the Reserve Bank's overriding commitment to the inflation target.

1. Introduction

Real interest rates lie at the heart of the transmission mechanism of monetary policy. Investment spending is affected by the cost of capital, and this provides a link between the financial sector and the macroeconomy. The business cycle and the transmission of economic policies in turn are influenced by business investment as well as household investment and consumption.

Although in the long run real interest rates are determined by real factors such as the propensity to save and the productivity of capital, monetary policy can impact on the real interest rate in the short to medium term. In South Africa attention was focused on real interest rates particularly in the aftermath of the 1997/98 Asian crisis, when short-term real interest rates became highly positive. This paper attempts to put the issue of South African real interest rates into historical and comparative perspective. The main focus is on comparing South Africa's real interest rates to those prevailing internationally, and on drawing some policy conclusions.

What emerges from the analysis is that, viewed historically, South Africa's real interest rates tended to broadly follow international trends. The periods when there were significant exceptions were during the 1980s, around the debt crisis and financial sanctions period, and since 1995. This is particularly the case with the short-term rate. Although South Africa's long-term rates do not seem out of line with international levels, particularly once we account for risk premiums, short-term rates are higher, due in part to monetary policy decisions. This situation is however consistent with the experiences of other countries (e.g. Australia and New Zealand) that have opened up their capital accounts, and at the same time also adopted strong anti-inflation policies. Where the actual inflation rate is above the target rate, we would expect short-term real rates to be high.

This paper is organised as follows: Section 2 briefly considers some of the theoretical issues relating to real interest rates, and Section 3 discusses the determinants of real interest rates. Section 4 considers measurement issues: many of the differences in observed rates are affected by how we actually measure real interest rates, particularly inflation expectations. Section 5 analyses historical trends in real interest rates in South Africa and internationally, and looks at the various causes of higher interest rates internationally since the 1980s. The question of whether current South

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African interest rates are high, in an historical and international context, is addressed in this section. Section 6 presents empirical evidence of a long-run linkage between South African and international real interest rates, and Section 7 concludes.

2. Theoretical considerations

The standard form of expressing the real interest rate is based on the Fisher equation, in terms of which the real interest rate (r^e_t) on an m-period bond held to maturity in period $t+m$ is equal to the corresponding nominal interest rate minus the expected inflation rate over the period:[2]

$$r^e_t \cong i_t - E_t\pi_t \qquad (1)$$

where i_t is the nominal interest rate on the m-period bond held to maturity in period $t+m$, and $E_t\pi_t$ is the expectation at time t of the rate of inflation from period t to $t+m$.

2 More precisely, the equation is given by

$(1+ r^e_t) = (1+ i_t)/(1+ E_t\pi_t)$
or
$r^e_t = (i_t - E_t\pi_t)/(1+ E_t\pi_t)$.

In the open economy context, if capital is perfectly mobile and real exchange rates converge to their equilibrium levels, *ex ante* real interest rates should move together in the long run. To see this, consider the analytical underpinnings of the relationship between international real interest rate differentials and real exchange rates. The differential between nominal interest rates at home and abroad may be described by the uncovered interest parity relationship with a risk premium

$$i_t - i^*_t = [E_t s_{t+m} - s_t] + \eta_t \qquad (2)$$

where s_t is the (log of the) nominal exchange rate (expressed as home currency to foreign, e.g. rand per dollar), $E_t s_{t+m}$ is the expectation at time t of this exchange rate in period $t+m$, and η_t is a risk premium. A star superscript denotes a foreign variable.

By definition, the real exchange rate q_t is given by

$$q_t = s_t - p_t + p^*_t \qquad (3)$$

where p_t (p^*_t) is the log of the home (foreign) price level. Using the approximations

$$E_t p_{t+m} \cong p_t + E_t\pi_t \; ; \; E_t p^*_{t+m} \cong p^*_t + E_t\pi^*_t \qquad (4)$$

where $E_t\pi_t$ ($E_t\pi^*_t$) is the expectation at time t of inflation over the period from t to $t+m$ at home (abroad), and substituting from the expectation of (3) into (2)

$$i_t - i^*_t = [E_t q_{t+m} + (p_t + E_t\pi_t) - (p^*_t + E_t\pi^*_t)] - [q_t + p_t - p^*_t] + \eta_t \qquad (5)$$

i.e.

$$(i_t - E_t\pi_t) - (i^*_t - E_t\pi^*_t) = [E_t q_{t+m} - q_t] + \eta_t \qquad (6)$$

and using the Fisher equation to define the real interest rates r_t, r^*_t

$$r_t = i_t - E_t\pi_t \; ; \; r^*_t = i^*_t - E_t\pi^*_t \qquad (7)$$

the real uncovered interest parity relationship with a risk premium is

$$r_t - r^*_t = [E_t q_{t+m} - q_t] + \eta_t$$

or

$$r_t = r^*_t + [E_t q_{t+m} - q_t] + \eta_t \qquad (8)$$

The extent to which real interest rates move together in practice may therefore shed some light on either the degree of capital mobility, real exchange rate convergence, or the presence of a time-varying risk premium. It follows therefore that to the extent that real interest parity fails to hold, a risk premium or discount can be said to exist, reflecting exchange rate or political uncertainties, administrative restrictions or other considerations. Increased liberalisation of capital markets in the 1980s should have strengthened the link between different interest rates.

3. Determinants of real interest rates

The classical view of the real interest rate is that it reflects the forces of productivity and thrift – the (marginal) productivity of capital, which determines the demand for capital, and the forces behind saving behaviour. A more Keynesian view is that "the" interest rate is determined in stock markets as portfolio holders choose between safe and risky assets and make intertemporal choices. The traditional view argues that there is no impact of monetary policy in the long run, and in the long run the real interest rate is only determined by the fundamentals of productivity and thrift.

However a new view argues that intertemporal arbitrage should ensure that short-term interest rates, long-term interest rates, and expectations (including expectations about what policy makers will do) are closely linked. Allsopp and Glyn (1999) for example argue that given that there are different policy regimes, there can be no presumption that there is a unique fundamental, equilibrium, real long-term interest rate which will tend to rule independently of the monetary policy regime and the stance of other policies. Their framework leads them to conclude that "it would be wrong to think of the real interest rate as determined just by the fundamentals of productivity and thrift and independent of monetary policy. On the contrary, one would expect interest rates to depend, for long periods, on the monetary policy regime and the stance of other policies, such as fiscal policy" (Allsopp and Glyn, 1999: 15). This implies that the real interest rate is not necessarily constant over time, i.e. the equilibrium real interest rate can change as the policy regime changes.

Much of the empirical literature on real interest rates has focused on the causes of the higher levels of interest rates since the 1980s. This section gives an outline of some of the factors that have determined the real interest rate levels or movements.

3.1 Changes in savings

The role of reduced current and prospective saving in driving up interest rates, e.g. increased public dissaving through increased budget deficits, is seen by Blanchard and Summers (1984) as a possible cause of higher real interest rates in the US in the 1980s, although their findings do not give strong evidence for this. Similarly Mishkin (1988) and Huizinga and Mishkin (1986) underplay the impact of higher budget deficits.

Orr et al. (1995) show that much of the fall in saving in the 1980s was due to the reduction in government saving. The decline in savings ratios is linked to financial liberalisation (which may have reduced saving propensities by removing liquidity constraints); lower inflation (reduced precautionary saving) and longer-term demographic factors (an ageing population implies lower saving). In a similar vein Atkinson and Chouraqui (1985) identify the Federal budget deficit in the US, and a shift in the fiscal/monetary policy mix in Europe where higher budget deficits had to be financed in the face of increasingly non-accommodative monetary policy.

Helbling and Wescott (1995), Howe and Piggott (1991), Ford and Laxton (1999), and Chadha and Dimsdale (1999) show that higher levels of government debt are associated with higher real interest rates. The growth of public debt relative to GDP will require agents to adjust their portfolios to hold more government securities. The real yield on government bonds must rise to bring about this change in portfolios.[3]

3 This is qualified by the neo-Ricardian view that increases in the public debt will have no effect on the level of real interest rates as increased public borrowing is balanced by increased saving by the private sector to anticipate future tax liabilities.

3.2 Changes in investment

Blanchard and Summers (1984) identify the increased attractiveness of investment owing to increased profitability or reduced uncertainty, as a major cause of higher interest rates in the 1980s. Similarly Orr et al. (1995) argue that higher returns to capital, which were a consequence of structural economic reforms, trade liberalisation, lower inflation, and the elimination of restrictions on direct foreign investment caused investment ratios to rise in the 1980s. Furthermore, growing demands for investment funds in non-OECD countries also represented a source of upward pressure on interest rates. Atkinson and Chouraqui (1985) argue, however, that although increased investment is important, it is difficult to determine empirically.

3.3 Monetary policy

As noted above, the traditional view has been that monetary policy has no impact on the real interest rate in the long run, as argued in Chadha and Dimsdale (1999). This assumes that the full adjustment of nominal interest rates to inflation takes place. In reality, the process is likely to be slow, hence changes in the rate of monetary growth may be expected to have persistent effects on real interest rates and hence on other real variables, such as output and employment. Blanchard and Summers (1984) emphasise the anticipation of sustained tight monetary policy, i.e. tight monetary policy that is expected to maintain interest rates at values higher than their equilibrium level in the short run.

High real interest rates have been observed in various countries for several months after the adoption of disinflation programmes. According to Kaminsky and Leiderman (1996), six months after the start of stabilisation plans in Argentina, Israel and Mexico in the mid-1980s, real interest rates were still of the order of 40-50 per cent per year. Interest rates of about 100 per cent were observed six months after the Bolivian stabilisation in 1985. High real interest rates of 5-6 per cent were observed in OECD countries following reductions in the inflation rates in the early 1980s. One explanation is a reflection of a shortage of liquidity induced by contractionary monetary policy. Kaminsky and Leiderman offer an alternative explanation which is that high *ex post* real rates can be explained in terms of an *ex post* error in inflation expectations, which reflects a lack of credibility of the low-inflation policy. If there is an expectation that high inflation will return, nominal rates will remain high. Over time as the new policy gains credibility, expectations of inflation will be revised downward, and nominal (and real) interest rates exhibit a gradual decline. Because expected inflation exceeds the actual outcome, *ex ante* real interest rates will be lower than those observed *ex post*.

3.4 Financial market deregulation

The regulation and deregulation of capital markets will have consequences for real interest rates. Governments faced with the financing of large budget deficits have attempted to reduce their own costs of borrowing by imposing restrictions on other borrowers. The removal of such restrictions will tend to raise real interest rates, for example the removal of prescribed asset requirements in South Africa during the 1980s and the relaxation of exchange controls. Similarly, Jenkinson (1999) has argued that real interest rates in the UK increased following the abolition of prescribed asset requirements as well as the abolition of exchange control in 1979.

3.5 Risk premiums

High rates on long bonds do not necessarily imply high expected short rates, but may instead reflect an increase in the risk premium required to hold long bonds, as reflected in Equation 8 above. Here changes in asset prices and returns reflect portfolio shifts rather than shifts in saving or investment. Over time the risk premiums on different types of security could be expected to vary, and this could help to explain changes in the real interest rate on individual types of security.

3.6 The impact of taxation

Atkinson and Chouraqui (1985) emphasise the impact of taxation although they find that it is difficult to confirm the influence. Similarly Chadha and Dimsdale (1999) argue that lower business taxes and high profitability would have contributed to the high real rates of the 1980s.

Although, as seen, there are a number of factors influencing the real interest rate, Atkinson and Chouraqui argue that all of these could have had some influence at one time or another, but none has a dominant monocausal role.

4. Measurement issues

One of the most intractable problems encountered in the study of real interest rates is the problem of measurement. This includes not only the issue of measuring inflation expectations, but also of deciding which interest rate to measure and the time horizon over which it should be measured. Blinder, commenting on Blanchard and Summers (1984), notes that the margin of uncertainty when measuring real interest rates is enormous. He shows, using Blanchard and Summers' data, that "from 1978 to 1984 … the real short term rate in the United Kingdom went up by either 8.2 points or 2.3 points depending on how you measure it. Between 1980 and 1983 … the real short rate in West Germany either rose 1.9 points or fell 1.8 points!" (Blanchard and Summers, 1984: 326). He argues that the margin of error with respect to long rates is even larger, and concludes that inferring the slope of the term structure of real interest rates is a hazardous and probably impossible enterprise in the absence of indexed bonds.

4.1 Time horizon

In general, the focus of empirical studies has been on long-term rates on the grounds that they impact more fundamentally on savings and investment decisions than short-term rates. Jenkinson (1999) argues for example that a 5-10 year time horizon is most relevant to most companies' investment decisions, while Scott (1993) also emphasises the fact that the long-term rate is a better indicator of the future cost of servicing the national debt.

However, since monetary policy has a direct effect on short-term rates, and if we are interested in the impact of official actions on interest rates, then it is necessary to look at short-term rates. It is also often the case that smaller businesses, particularly in

South Africa, finance themselves not through equity finance or long-term borrowing but through short-term overdraft facilities. In addition, most consumer durable expenditure as well as mortgage finance is related to the short-term prime overdraft rate.

Furthermore, the problems of calculating *ex ante* real interest rates (discussed below) are reduced when dealing with short-term rates because systematic errors in inflation forecasting are less likely over short time horizons. This makes actual inflation a good proxy for expected inflation and so expected and realised real rates will be similar. Blanchard and Summers (1984) place more emphasis on the computation of real *ex post* short rates on the grounds that the computation of long-term rates (because of the problem of measuring long-term inflationary expectations) is necessarily arbitrary.

4.2 Which rate (given the time horizon)?

In analysing trends in real interest rates, inevitably a single rate is examined. However as Orr et al. (1995) note, this ignores the fact that different agents are charged different rates, that there are cross-country differences in the relative importance of maturity structures in financing, and that different risk premiums face similar categories of borrowers. In addition, different tax regimes affect the real interest rate, which further complicates cross-country comparisons. A further factor complicating cross-country comparisons is the fact that financial liberalisation occurred at different times and speeds across countries, affecting the measurement of effective interest rates and possibly putting upward pressure on real rates through a negative impact on saving.

Various nominal interest rates are used in the literature as a basis for real interest rate calculations. For example, Jenkinson (1999) and Breedon et al. (1999) focus on returns on government securities to approximate the return on a riskless asset. Chadha and Dimsdale (1999) and Ford and Laxton (1999) use a money-market rate for the short-term real interest rate on the grounds that it is closer to the borrowing costs of the private sector but will involve risk premiums compared to government securities.

4.3 Measures of inflation expectations

Given that real rates are the nominal yields on bonds adjusted for expected inflation over the life of the bond, the problem arises in measuring the unobservable long-run inflationary expectations. This section briefly reviews some of the different methodologies used to estimate expected inflation. In general, five different approaches may be identified.

(i) The simplest approach to estimating expected inflation is to use a measure of observed past inflation. Assuming again an m-period bond, this approach results in what is called the conventional real interest rate (r^c_t)

$$r^c_t = i_t - \pi_{t-j,t} \tag{9}$$

where $\pi_{t-j,t}$ is the rate of inflation from period t-j to t. Real interest rates measured in this way are simple to calculate, but are clearly problematic when inflation expectations are not static. This is especially the case when long-term expectations are involved.

(ii) The second approach uses the realised inflation rate over the period as a proxy for expected inflation. This generates the *ex post* measure of the real interest rate (r^p_t)

$$r^p_t = i_t - \pi^*_{t,m} \tag{10}$$

where $\pi^*_{t,m}$ is the actual rate of inflation from period t to $t+m$. The *ex post* real interest rate is not known when decisions are taken, so its usefulness depends on the extent to which expectations approximate realised outcomes.[4]

(iii) An alternative approach is to compute an inflation forecast from a time series model such as an ARIMA model, or by "smoothing" the inflation series using, for example, a long moving average or some smoothing technique such as a Hodrick-Prescott filter. In the former case, current price increases are treated solely as a function of constant and past values of inflation and this method is therefore subject to the criticism that the procedure is too inflexible and fails to make use of some information which is both relevant and available.[5] Smith (1996) uses a quarterly ARMA forecast of CPI inflation and similarly, Begum (1998) uses the forecast from an ARIMA (4,1) model of inflation. Blanchard and Summers (1984) and Barro and Sala-i-Martin (1990) make expected inflation a mathematical function of past inflation.

Computing expected inflation by "smoothing" the inflation series is a commonly used technique. For example, Pain and Thomas (1997) proxy inflation expectations over the next three months by taking a simple four-quarter moving average of quarterly inflation. Smith (1996) and Pain and Thomas (1997), in analysing long-term rates, use a two-year centred moving average of CPI inflation. Orr et al. (1995) proxy trend inflation by the low-frequency component of the GDP deflator computed by a Hodrick-Prescott filter. This measure incorporates both forward and backward-looking elements of the inflation process in a type of "two-way averaging" process, and therefore uses information not available to *ex ante* forecasts.

A problem when working with long-term rates is that if we are for example looking at 10-year rates, ten years of observations are lost if we are measuring expectations on an *ex ante* basis. Most studies therefore use forecasts which are confined to one or two years ahead at most. Scott's (1993) view is that the best procedure would be to do a thorough historical study of each period for which an estimate of long-term inflationary expectations is required. This has major difficulties in terms of constructing a consistent time series. The problem is compounded if cross-country comparisons are made. With respect to long-term rates, Chadha and Dimsdale (1999) contend that the determination of real long-term *ex ante* rates poses problems because of lack of knowledge about expected future rates of inflation and that holding period rates of return may well also differ from yields to maturity.

(iv) The fourth approach used in the literature is to use survey data on inflationary expectations. Mishkin (1988), however, argues that survey-based measures have their own problems as survey respondents may have little incentive to respond accurately. Furthermore he argues that "the behaviour of market expectations is driven by economic agents at the margin who are eliminating unexploited profit opportunities. Market expectations, therefore, are unlikely to be well measured by the average expectations of survey respondents" (Mishkin, 1988: 1064).

4 In this regard, if rational expectations are assumed, the inflation forecast error

$$\varepsilon_{t,m} = E_t\pi_t - \pi^*_{t,m}$$

is a martingale difference. Furthermore, from the definitions provided above,

$$r^p_t + \pi^*_{t,m} = r^e_t + E_t\pi_t$$

i.e.

$$r^p_t = r^e_t + (E_t\pi_t - \pi^*_{t,m}) = r^e_t + \varepsilon_{t,m}$$

Under rational expectations, then, the ex post *and* ex ante *real interest rates differ by a stationary component* $\varepsilon_{t,m}$. *The two rates will therefore have the same long-run time series properties in that a test for a unit root in the* ex post *real interest rate series may be interpreted as a test for a unit root in the* ex ante *real interest rate. Also, it follows that the* ex post *rate will tend to exhibit less persistence than the* ex ante *rate (see Section 4).*

5 See for example Scott (1993: 5).

An additional problem for time-series analysis is that there are very few series of inflationary expectations based on survey data.

(v) Finally, the emergence of index-linked government bonds has provided a direct measure of long-term real rates and allows for direct measures of inflationary expectations. In the UK, for example, the direct measure for long-term real rates provided by index-linked bonds is less variable than most proxy measures. Also, the index-linked yield tends to be below the proxy when current inflation is relatively low by historical standards and above the proxy when inflation is relatively high, which suggests that long-term inflationary expectations are relatively slow to respond to current actual inflation.[6]

6 This implies that countries with a history of high inflation will tend to pay significant inflation premiums in nominal bond yields until market participants are convinced of sustained price stability.

The difference between the yield on non-indexed and index-linked government bonds provides one measure of long-term inflation expectations, although it may also capture the effects of factors other than inflation expectations, including differences in tax treatment, inflation uncertainty and liquidity premiums (Orr et al., 1999). In addition there are important indexation lags in inflation-proof bonds and so they cannot be considered to be pure real bonds. Finally, the absence of a long historical data run of real yields makes inferences on long-term patterns highly problematic, especially in the case of South Africa where index-linked bonds are a relatively new phenomenon.[7]

7 In the South African case, the first issue was set at 6,5 per cent, which was the rate (arbitrarily) set by the Treasury, rather than being a true measure of market expectations.

4.4 Does the choice of an inflation expectations proxy really matter?

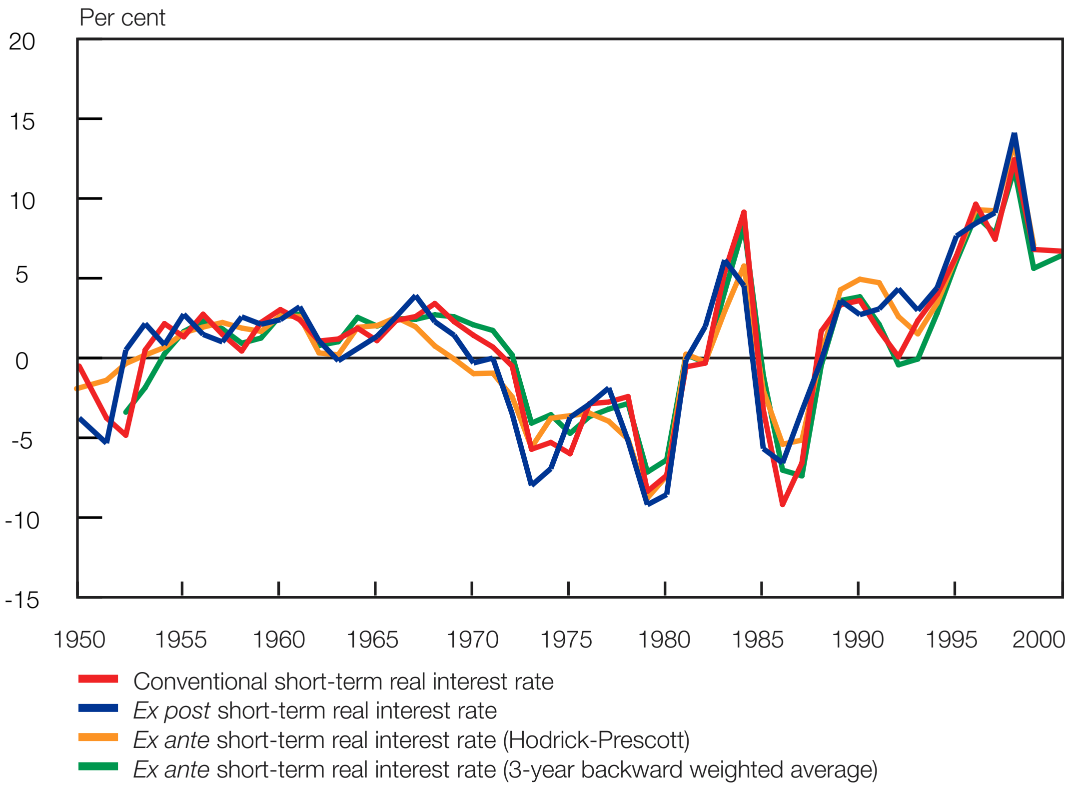
Despite the differences in approaches to measuring expectations, Blanchard and Summers (1984) found little difference over the long run between *ex post* and *ex ante* measures of the real rates. They attribute this to the argument that over the very long run the subjective prior about the inflation process is more likely to coincide with its *ex post* realisation.

A comparison by Orr et al. (1995) of a range of proxies for inflationary expectations concludes that medium-term trends in real interest rates are not substantially affected by the exact choice among a range of reasonable proxies for trend inflation, although the timing of turning points can differ significantly in periods where inflation is highly variable. Chadha and Dimsdale (1999) argue that as long as agents do not make systematic errors in their forecasts of inflation, the difference between predictions of inflation and actual inflation is likely to be small, particularly over long periods of time.

However, as noted above, Blinder did find considerable differences (Blanchard and Summers, 1984). Similarly, Atkinson and Chouraqui (1985) show that differences between real long-term interest rates as conventionally measured and their *ex post* values have often been substantial. They argue that in many cases a failure to anticipate the inflation of the 1973-75 period resulted in significantly negative real returns despite real rates that were apparently positive. They found that although at times there were differences between the conventional and the *ex ante* measures, often they were similar. Also, the substantially negative conventional real interest rates existing around 1974-75 were not, except in Italy, realised *ex post*. It would appear that the differences between the measures become more pronounced during periods of inflation volatility and unexpected exchange rate changes.

Figure 1 shows various alternative measures for South Africa, and it can be seen that although these measures do generally move together, the *ex post* measure tends to deviate from the other measures during periods when the inflation trend is changing. So, for example, the lower *ex post* real interest rates of the early to mid-1970s reflected a situation where inflation was higher than expected, whereas the early 1990s was a period when the inflation rate fell by more than expected. The various *ex ante* measures move sufficiently closely to ignore the differences. Sinçe 1993 the different measures, including the *ex post* measures, have coincided sufficiently to ignore this potential problem.

Figure 1 South Africa: alternative measures of short-term real interest rates



5. Historical trends

Given the multiplicity of alternative measures, differences in measured real interest rates are inevitable. Despite these problems and differences, however, certain common trends emerge from the literature. Most of the existing analyses of historical trends in real interest rates have been conducted on industrialised countries, and examine three main subperiods of the post-1950 experience: the 1950-69 period corresponding with the "golden age" of the post-World War II boom; the 1970-79 period corresponding with the turbulence and inflation of the oil crises; and the post-1980 period which was characterised by greater financial market liberalisation and more emphasis on inflation control.[8] A common result in these studies is that the first of these periods was characterised by positive real interest rates averaging around 2 per cent, the second by negative or extremely low positive real rates, and the 1980s and 1990s by positive real rates which were higher than in the previous periods, although generally real rates in the 1990s tended to be lower than in the 1980s.

8 See for example Allsopp and Glyn (1999) and the studies cited therein, and Levy and Panetta (1996).

In this study, short and long-term real interest rates were calculated for South Africa and a selection of other countries, at the annual and monthly frequencies. A discussion of the data used to calculate these real interest rates appears in Appendix 1, and plots of the rates are presented in Figures 2 – 3. The discussion in this section is based on the annual data set, since this covers the longest time-span. However the trends that emerge at the various frequencies are largely consistent. In line with the studies of the evolution of real interest rates cited above, the plots suggest that the South African experience in the post-1950 period may usefully be examined over the same three periods.

Figure 2 Short-term real interest rates

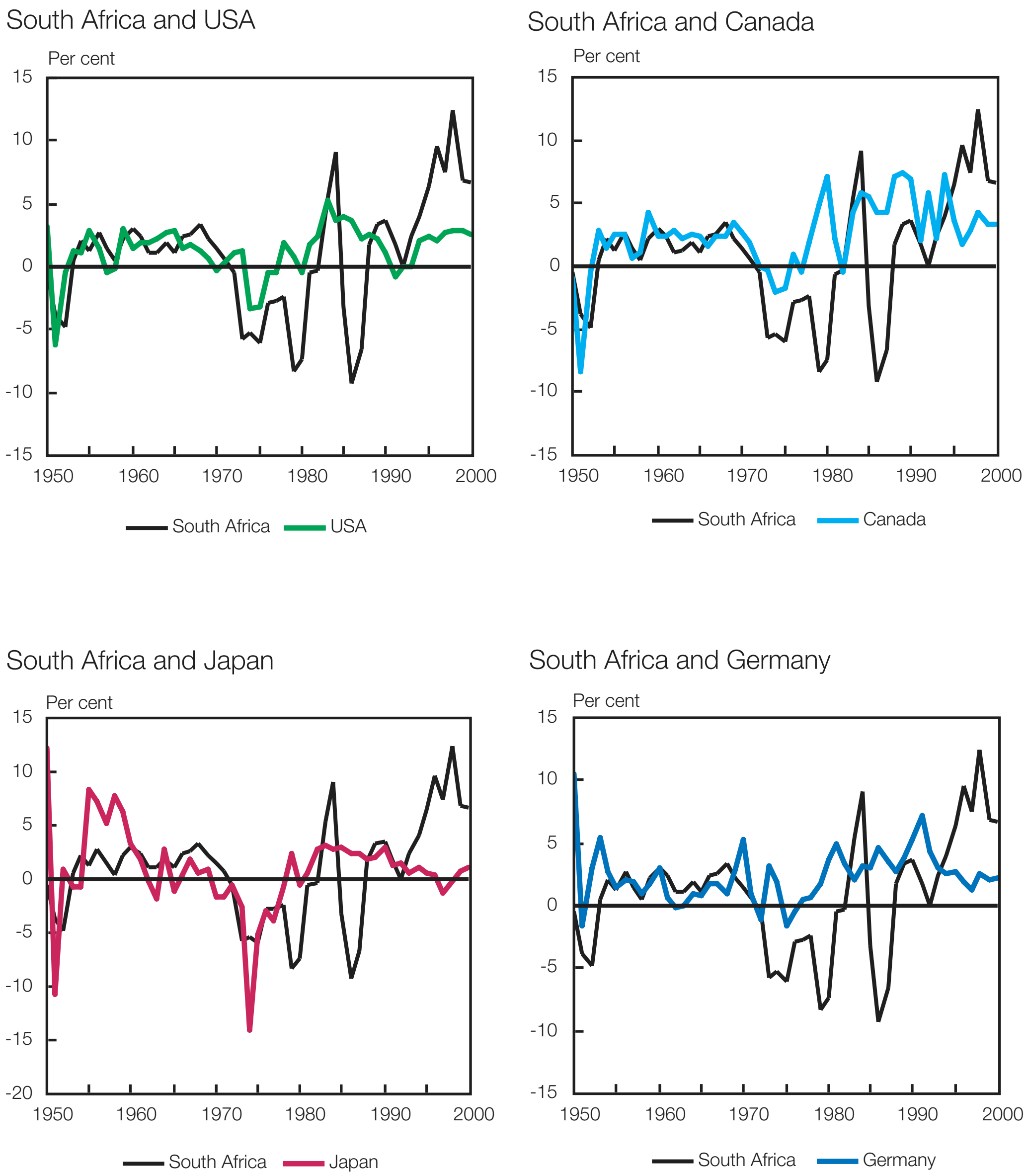
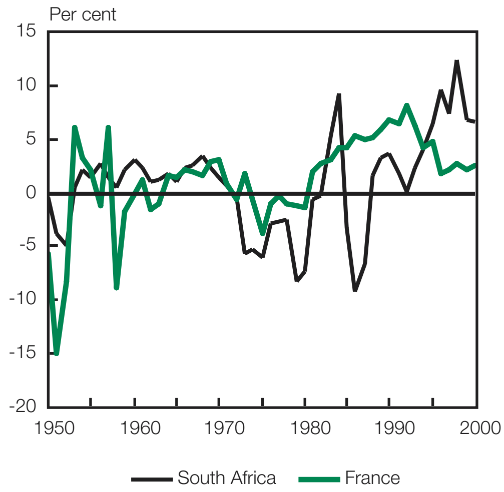
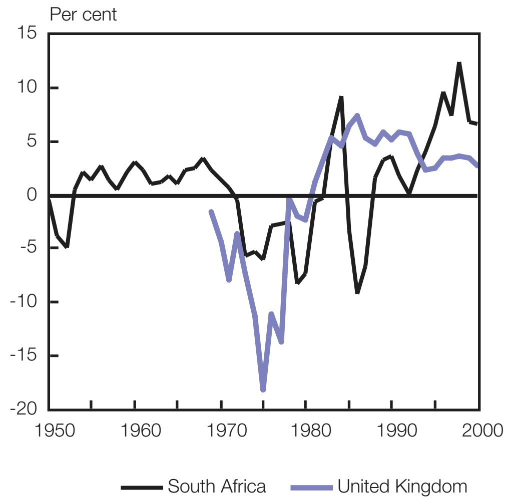


Figure 2 Short-term real interest rates (continued)

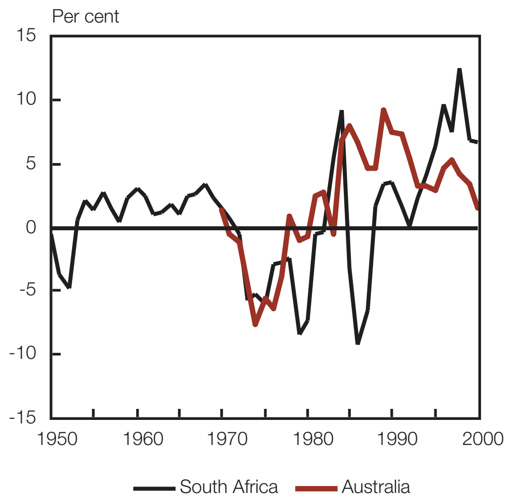
South Africa and France



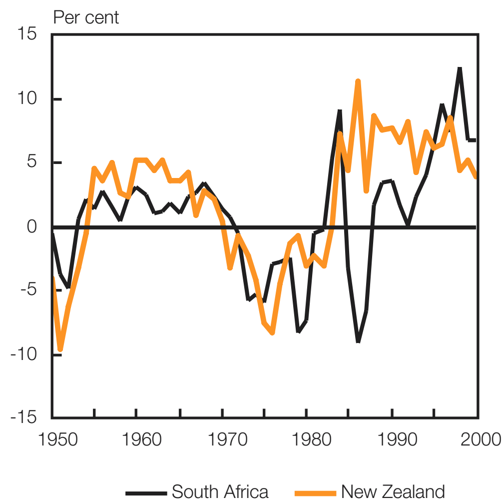
South Africa and United Kingdom



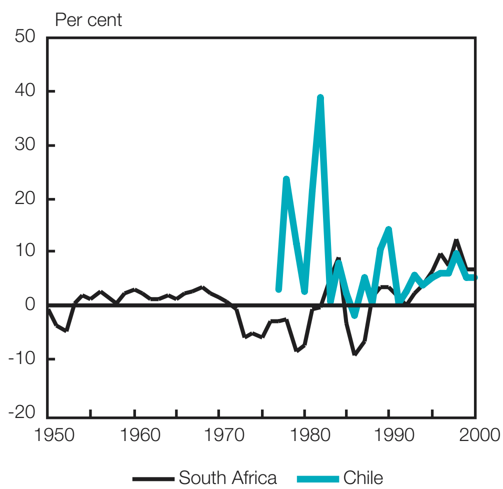
South Africa and Australia



South Africa and New Zealand



South Africa and Chile



South Africa and Mexico

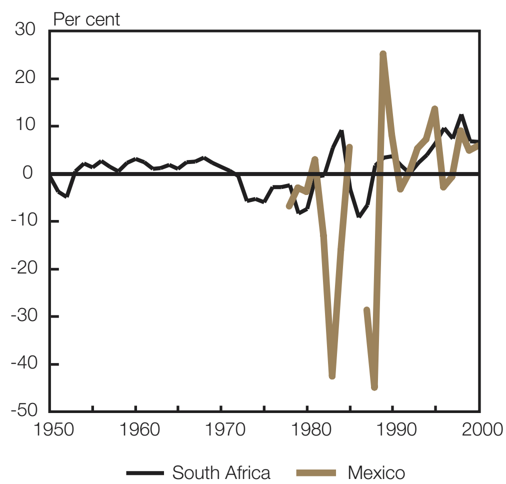
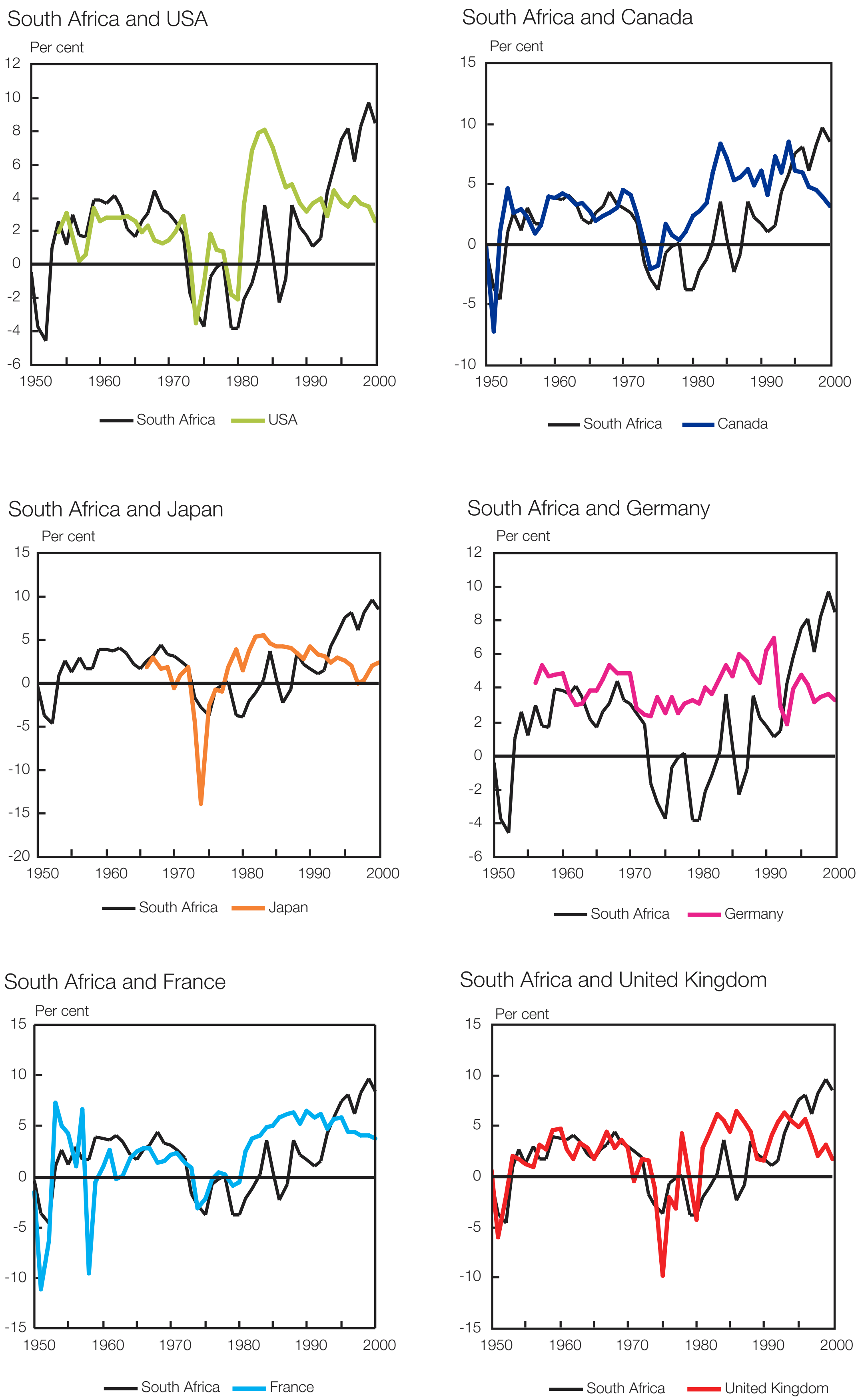


Figure 3 Long-term real interest rates



In the 1950-69 period, as Table 1 shows, South African real interest rates were relatively low, but positive, with the short-term *ex post* real interest rate averaging 1,2 per cent and the long-term rate 1,9 per cent. From a comparative international perspective, South Africa's average short-term real interest rate over this period was above that of France (-0,6 per cent), but lower than or equal to those of the other countries surveyed. For example the US rate was 1,2 per cent, Germany 2,0 per cent, and New Zealand 1,5 per cent. The average long-term rate of 1,9 was in line with that of the UK, US and Japan, but well below that of Germany (4,4 per cent). Australian and New Zealand rates were extremely low. As mentioned earlier, financial market and other restrictions in most countries at this time complicate the comparisons.

Table 1: Real interest rates since 1950
(period averages, per cent per annum)

	SA	US	Germany	France	UK	Japan	Australia	NZ	Canada
Real short rate:									
1950-69	1,2	1,2	2,0	-0,6		2,2		1,5	1,5
1970-79	-3,2	-0,3	1,1	-0,3	-8,0	-3,1	-2,9	-3,3	0,7
1980-89	-0,8	2,7	3,5	3,6	4,2	2,0	4,4	3,4	4,8
1990-2000	5,6	1,6	3,2	4,4	3,9	0,8	4,4	6,2	3,9
Real long rate:									
1950-69	1,9	2,2	4,4	0,6	2,0	2,1	0,3	0,6	2,2
1970-79	-0,5	0,4	3,1	0,1	-0,7	-1,4	-1,4	-4,0	1,1
1980-89	0,0	5,0	4,6	4,4	3,7	4,0	5,0	2,0	5,2
1990-2000	5,7	3,6	4,0	5,1	4,0	2,4	5,6	5,8	5,5

Source: Calculated from IMF *International Financial Statistics* (see Appendix 1 for details).

Between 1970 and 1979, inflation rates increased relative to nominal bond yields in most countries, resulting in lower measured real rates. In South Africa, in line with the experience of other countries, the increases in inflation appear to have been sufficiently large (and unexpected) to generate negative real interest rates. The mean short-term real rate over this period was -3,2 per cent, similar to that of Australia, New Zealand and Japan. The long-term rate was moderately negative at -0,5 per cent. The only country to record a significantly high long-term real rate was Germany, at over 3 per cent, compared to a G-10 average of just over 1 per cent.

This period was one of high inflation, generated in part by the oil crises, as well as continued controls on capital movements. Combined with the widespread use of prescribed asset requirements, governments were assured of a demand for their assets, even at negative rates. This was particularly the case in the United Kingdom and South Africa. For prolonged periods in the UK, for example, the realised real return on government bonds was negative. Given that this was also the case in South Africa over similar periods, the reasons may be relevant. Jenkinson (1999) suggests that it could be unanticipated inflation (i.e. the market systematically underestimating inflation), implying that the *ex ante* real rate may have been higher. This does not tell us why real rates on Treasury bills were negative for such a prolonged period, particularly since we are looking at very short maturities. A more plausible explanation offered by Jenkinson is that the UK government was able to get away with paying very low nominal rates on its debt, and so was able to extract considerable seigniorage from investors. Exchange control limited the ability of investors to seek higher returns abroad, and institutional demand for Treasury bills was more or less assured.

In 1979 Thatcher removed exchange controls, and in 1981 started issuing inflation-linked bonds, which explains why negative real rates have become a thing of the past. As Jenkinson notes, "in no year since 1980 have real returns on Treasury Bills been negative, and it is hard to believe (in the absence of the reimposition of capital controls) that they will be in the future" (Jenkinson, 1999: 119).

Finally, since 1980, an era of positive real interest rates has again emerged. The early 1980s saw higher real rates in the US in particular (the dollar over-valuation period), and periods of financial market liberalisation in various countries which resulted in significantly higher interest rates. Contrary to the international trend, short-term real interest rates in South Africa remained negative on average in the 1980s. This, however, masks a high degree of volatility in the real interest rate which fluctuated within a range of +10 per cent and -10 per cent. This period was firstly one of financial market and capital account liberalisation, with the abolition of the financial rand in 1983 and the abolition of prescribed asset requirements. These factors led to the high real rates in 1984/85. In 1985 the debt crisis and financial sanctions caused a reversal of the capital account liberalisation and a collapse in domestic investment, resulting in negative real rates. In mid-1988, the lack of access to foreign saving led to tighter monetary policy as higher investment and consequent import demands hit against the balance of payments constraint. South Africa's average long-term rates which were marginally positive, were significantly lower than those of all the other countries surveyed, as shown in Table 1.

The average rates for the 1990s show that South African real interest rates did not differ significantly from those prevailing in a number of other countries. However, as can be seen in the various graphs in Figures 2 and 3, the pattern for the period from 1995 was significantly different from most of the other countries. This is also illustrated in Tables 2 and 3 where the annual differentials since 1995 between South Africa and selected countries are shown. The graphs also show that the trend in the 1990s for the industrialised countries has been downward, despite a general increase in rates in 1994.[9]

9. This is in line with Orr et al. (1995), who show that in the early 1990's there was a tendency for real interest rates to decline in most countries after the high real interest rates of the 1980s. This decline was reversed in 1994, and in a number of countries there was a significant widening of interest differentials vis-à-vis the major economies.

Table 2: Short-term real interest rate differentials
(SA real rates minus foreign real rates)

	1994	1995	1996	1997	1998	1999	2000
SA - USA	1,8	4,0	7,6	4,8	9,5	4,0	4,1
SA - Canada	-3,3	2,8	8,0	4,6	8,2	3,5	3,5
SA - Japan	2,9	5,8	9,3	8,7	12,6	6,0	5,6
SA - UK	1,7	3,8	6,2	4,0	8,8	3,3	3,9
SA - France	-0,1	1,6	7,8	5,3	9,7	4,6	4,2
SA - Germany	1,4	3,6	7,8	6,2	9,9	4,7	4,5
SA - Greece	-5,6	-2,7	1,3	-1,5	-	-2,4	1,7
SA - Norway	-3,4	0,3	3,1	-1,1	8,1	1,7	2,8
SA - Australia	0,7	3,5	5,1	2,2	8,3	3,5	5,3
SA - New Zealand	-1,4	2,1	4,9	4,5	4,7	1,6	0,8
SA - Turkey	55,3	44,5	40,0	26,2	30,1	11,7	-
SA - Brazil	-	-	-1,8	-10,6	-13,9	-14,6	-3,8
SA - Chile	0,3	0,9	3,5	1,6	2,6	1,6	1,3
SA - Mexico	-3,2	-7,0	12,6	8,3	3,6	2,0	1,0
SA - Korea	5,2	5,9	9,6	6,9	16,9	4,6	4,0

Source: Calculated from IMF *International Financial Statistics* (see Appendix 1 for details).

Table 3: Long-term real interest rate differentials (SA real rates minus foreign real rates)

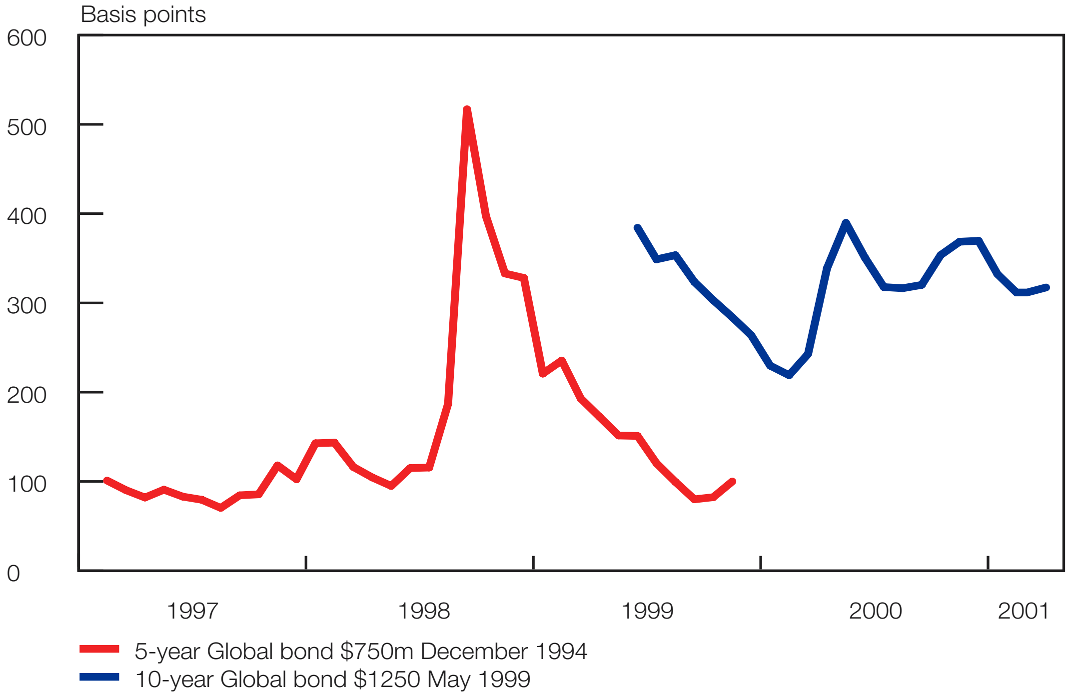
	1994	1995	1996	1997	1998	1999	2000
SA - USA	1,3	3,7	4,6	2,1	4,5	6,3	5,8
SA - Canada	-2,6	1,4	2,2	1,3	3,8	5,7	5,3
SA - Japan	2,8	4,9	6,0	6,2	7,8	7,6	6,1
SA - UK	0,3	2,7	2,5	2,2	6,2	6,6	6,7
SA - France	0,1	1,7	3,8	1,7	4,2	5,6	4,7
SA - Germany	1,9	2,7	3,9	3,0	4,8	6,0	5,2
SA - Netherlands	1,4	2,2	3,7	2,5	5,3	7,0	5,5
SA - Norway	0,1	3,1	3,4	3,6	5,1	6,7	5,2
SA - Australia	-1,3	3,0	2,6	-0,5	3,6	5,1	6,7
SA - New Zealand	0,7	3,3	2,4	0,1	3,1	3,5	4,3

Source: Calculated from IMF *International Financial Statistics* (see Appendix 1 for details).

The factors that have contributed to this divergence since the mid-1990s include

- the abolition in 1995 of the financial rand which had provided partial insulation to South African rates; other countries liberalised at earlier times, which accounts for the higher rates of Australia and New Zealand in the early 1990s;
- the 1996 rand crisis which resulted in tighter monetary policy;
- the tight monetary policy reaction to the sharp depreciation of the rand following the Asian and Russian crises in 1998. This resulted in record highs in real short-term interest rates. Not all countries responded to the Asian crisis by tightening monetary policy, for example the differential with Australia where rates were not raised, increased from 2,2 per cent in 1997 to 8,3 per cent in 1998;
- the higher risk premium implicit in South African real rates. This would be applicable more to long-term rates. Figure 4 shows that the country risk premium on South Africa's 10-year 1999 global bond issue (i.e. the spread between the yield on this bond and a comparative US Treasury bond) is around the 300 basis

Figure 4 Country risk measured by bond spreads



point level. If we consider that domestic bonds would also carry a currency risk premium (i.e a risk of real depreciation), it does not appear that long-term rates are excessively high by international standards.

During 1999 short-term rates declined as the Reserve Bank's repurchase rate was reduced. By the end of 2000 rates had reached the levels prevailing around the time of the abolition of the financial rand. Short-term real interest rates still appear to be high in both an international and historical context at present. However, the differential between South Africa's short-term real interest rates and those of other countries has declined. If, as anticipated, the long-term downward trajectory of the CPI continues, the real rate will rise relative to other countries, unless the repurchase rate is reduced. (It should also be noted that as these are annual data they do not reflect the recent declines in official interest rates in a large number of countries.)

6. Linkages between real interest rates

At a theoretical level, Section 2 shows that, assuming perfect capital mobility, real interest rates will be equalised if real exchange rates are expected to remain constant. However, we know that actual real exchange rates have diverged substantially, and therefore we do not know if any observed divergence of real interest rates reflects an expectation of real exchange rate changes, or other factors that may cause interest rates to diverge. This issue has been the focus of a number of studies, and although the evidence is inconclusive, there does seem to be some convergence towards real interest rate parity. Again, most of the studies focus on the industrialised countries.

In empirical studies, Cumby and Mishkin (1986) find a significant positive correlation between real rate movements in the US and seven other industrialised countries, and the degree of linkage, though significantly positive, was also significantly less than complete. They also suggest that real rates within Europe were not more closely linked with one another than they were with US real rates, although no causality is implied. More recently, Pain and Thomas (1996) find evidence of significant cross-country linkages between real interest rates both cyclically and in the long run. They also find evidence of a "single" European short-term interest rate, with Germany the dominant player, but the hypothesis that US rates determine the trend in European rates cannot be rejected. Their study also shows that linkages between long-term rates among the G-3 appear stronger in the post-1980 period, consistent with increased capital market integration.

Allsopp and Glyn (1999) show that the real interest rate shifts are surprisingly similar between countries. This does not mean there is a single world interest rate towards which all countries must converge, as correlations between interest rates on a year-to-year basis within the successive long periods are not that high. "Surprisingly, given increasing capital mobility, this is particularly the case for real interest rates in the most recent period ... So it would be wrong to think of 'the world interest rate' as much more than summarising average experience. However, country experience has not been so diverse as to make such an average a misleading abstraction" (Allsopp and Glyn, 1999: 2).

By contrast, Breedon et al. (1999) find it is hard to argue that long-term real interest rates are converging to a single world rate. Furthermore, they argue that the large and persistent differences in real interest rates across countries cannot be explained in terms of real exchange rate expectations. Macroeconomic indicators from the countries concerned appear to play some role in accounting for these differences. The forces operating in the opposite direction to a unified rate include transaction costs in converting between currencies, country-specific risks, and any "home-country biases" which are present. These forces result in persistent inter-country real interest rate spreads which cannot fully be explained by expected changes in bilateral real exchange rates.

If domestic real interest rates are indeed determined by developments abroad, this removes an important avenue for monetary policy to influence the domestic economy. Less than complete linkage has important implications for monetary policy – consistent with models which allow monetary policy to have real effects. However, unless we know the cause of the differences in real rates, we cannot say whether we have a situation of money neutrality and real rate differences arise due to relative price movements resulting from real shocks to the economy. Theoretically there are various reasons why real interest rates can diverge, including sticky price models. In a world of risk-averse economic agents, real rates can differ across countries because there are risk premiums in the forward exchange market and for securities denominated in different currencies, and these premiums differ across countries, and undergo variation over time. Different real interest rates leave open the possibility for policy-makers to exercise some control over their domestic real rate, relative to the rest of the world.

6.1 Testing real interest rate linkages

From Equation (8), assuming a constant real exchange rate and no risk premium, we obtain $r_t = r^*_t$, the real interest parity (RIP) condition. Effectively this implies that the nominal interest rate differential adjusts fully to the expected inflation differential, ensuring constant real interest rates at home and abroad, and parity between countries.

Most tests of the RIP condition proceed by estimating some form of the regression equation

$$r_t = \alpha + \beta r^*_t + \epsilon_t \tag{11}$$

and testing whether $\alpha = 0$ and $\beta = 1$. The choice of the appropriate econometric methodology depends upon the time series properties of the real interest rates concerned, although there appears to be no consensus about these properties despite intensive study (Phillips, 1998).[10,11] The approach adopted here is to impose the conditions noted above on α and β in Equation (11), and then consider whether the real interest differential $r_t - r^*_t$ is mean reverting. In general, if the real interest rate differential is mean reverting over time, then real interest parity may be seen to hold as a long-run equilibrium condition. The intention is to test for mean reversion in short-term real interest rate differentials calculated at the monthly frequency (see Appendix 1), first using conventional *I(1)/I(0)* unit root tests (Section 6.2) and then employing a more general fractional integration approach (Section 6.3).

10 Although Fama (1975) found evidence of a constant real interest rate, subsequent work has often rejected this. A number of authors following Rose (1988) have found real interest rates to be I(1) nonstationary, although this is inconsistent with much theoretical work. More recently, it has been argued that real interest rates are neither I(1) nor I(0) but fractionally integrated of order I(d) with 0 < d < 1 (Lai, 1997; Phillips, 1998) or that they are constant but subject to infrequent regime shifts (Garcia and Perron, 1996).

11 This lack of consesus carries over to the literature on testing real interest parity. Some authors hold that real interest rates are I(0) (Fujii and Chinn, 2000), though others proceed on the basis that they are I(1) (Felmingham et al., 2000).

6.2 *I(1)/I(0)* unit root tests on the real interest differential

The use of standard unit root tests, such as the augmented Dickey-Fuller (ADF) test, to consider whether a series is *I(0)* and thus mean reverting is common in applied economics. It is well known however that these tests suffer from size distortions and low power (Kremers et al., 1992).[12] It is also important to note that the tests have an *I(1)* null hypothesis, which gives the unit root outcome ("no mean reversion") the benefit of the doubt in the testing procedure.

The approach adopted here is a confirmatory one which reports the results of two types of unit root test (in both cases a constant is included as the deterministic component). First, the "Generalised Least Squares" version of the ADF test (the DF-GLS$^{\mu}$ test introduced by Elliott, Rothemberg and Stock, 1996) is reported. Monte Carlo results suggest that this test is more powerful than the standard ADF test (Stock, 1994; Elliott, Rothemberg and Stock, 1996). Second, the KPSS test of Kwiatkowski et al. (1992), which has stationarity as the null hypothesis, is employed.[13] Appendix 2 provides a discussion of these tests and their application.

Given the different null hypotheses of these tests, it is necessary to say something about the interpretation of the results obtained. In general, when both a test with a unit root null (test 1) and one with a stationarity null (test 2) are undertaken, there are four possible outcomes (Amano and van Norden, 1992; Cheung and Chinn, 1994). First, test 1 does not reject and test 2 rejects, suggesting that there is a unit root. Second, at the opposite extreme, if test 1 rejects and test 2 does not, the implication is that the data are stationary. Third, if neither test rejects, then it would appear that the data are not informative enough to distinguish between a unit root and stationarity. Finally, if both tests reject their respective null hypotheses, the suggestion is that there is some form of misspecification (since at least one is suffering from Type 1 error). Neither of the last two outcomes allows conclusions to be drawn about the presence or absence of unit roots, and hence mean reversion, in the data.

Table 4 reports the results of the DF-GLS$^{\mu}$ and KPSS tests applied to the bilateral real interest rate differential between South Africa and each of the USA, UK, Germany, Japan and Canada. When the DF-GLS$^{\mu}$ test is considered, choosing the lag length by minimising the Schwarz Bayesian Criterion (SBC) (Schwarz, 1978) and computing finite sample critical values from the response surfaces provided by Cheung and Lai (1995), it is clear that the *I(1)* null is rejected in each case (at the 10 per cent level in the case of the differential with the UK, at the 5 per cent level in all

Table 4 DF-GLS$^{\mu}$ and KPSS tests on short-term real interest rate differentials[1]

	SA-USA	SA-UK	SA-Germany	SA-Japan	SA-Canada
DF-GLS$^{\mu}$ [2]	-2,240 (0) *	-1,931 (3) #	-1,998 (2)*	-2,366 (0) *	-2,416 (0) *
KPSS[3]	1,073 *	0,555 *	0,693 *	0,597 *	0,584 *

Notes:
1. # denotes significance at the 10 per cent level and * denotes significance at the 5 per cent level. The figure in round parentheses ( ) is the lag order, selected from a maximum order of 11 using the Schwarz Bayesian Criterion (SBC).
2. Finite sample critical values are generated from the response surfaces in Cheung and Lai (1995).
3. The null hypothesis for the KPSS test is stationarity (against a unit root without drift). The 5 (10) per cent asymptotic critical value is 0.463 (0.347). A truncation lag was selected using the $\ell 8$ rule of KPSS (1992), which sets ℓ = INT{8*(T/100)^(1/4)}.

12 Diebold and Rudebusch (1991) provide Monte Carlo evidence that these tests have particularly low power against fractional alternatives (discussed in Section 6.3).

13 Lee and Schmidt (1996) show that the KPSS test is consistent against fractional alternatives for |d| < 0,5 although rather large sample sizes are required to distinguish between long and short memory processes (fractional integration and long memory are discussed in Section 6.3).

other cases). Comparing the KPSS test statistics to the asymptotic critical values in KPSS (1992, Table 1), however, the null of stationarity is rejected at the 5 per cent level in all cases (in fact, at the 1 per cent level in the case of the SA-US differential). As noted in the earlier preliminary discussion regarding the interpretation of the results, these somewhat confusing results suggest misspecification. No conclusions may be drawn regarding mean reversion in the real interest rate differentials, and alternative specifications should be considered. In the next section this empirical contradiction is investigated further by considering a fractional integration approach.

6.3 A fractional integration approach to real interest rate differentials

The analysis of fractionally integrated processes allows for more subtle mean reverting behaviour in time series than that captured by the somewhat restrictive traditional approach discussed above.[14] The knife-edge distinction between the integer $I(0)$ and $I(1)$ processes, which restricted mean reverting dynamics to $I(0)$ processes alone, is generalised to allow non-integer orders of integration $I(d)$. More specifically, an $I(d)$ process with $0 < d < 1$ is also mean reverting, although sometimes rather persistent.[15]

14 Baillie (1996) provides a survey of long memory and fractional integration in econometrics.

15 In the sense that the autocorrelation function decays at a much slower rate than for a corresponding I(0) process.

Empirical work in this area is generally based on the autoregressive fractionally integrated moving average (ARFIMA) model introduced by Hosking (1981) and Granger and Joyeux (1980). A time series y_t $(t = 1, \ldots, T)$ is an ARFIMA (p, d, q) process if

$$\phi(L)(1 - L)^d \; y_t = \mu + \theta(L)\epsilon_t \tag{12}$$

where L is the usual lag operator, μ is any deterministic function of time, and $\phi(L)$, $\theta(L)$ are polynomials of order p, q respectively. The innovation process ϵ_t is white noise with mean zero and variance σ^2_ϵ, and the fractional differencing operator $(1 - L)^d$ is defined using the binomial expansion as

$$(1 - L)^d = \sum_{k=0}^{\infty} \Gamma(k-d)L^k / \Gamma(k+1)\,\Gamma(-d) \tag{13}$$

where $\Gamma(.)$ is the gamma function. Note that restriction of the differencing parameter d to integer values results in standard ARIMA models.

If all roots of $\phi(L)$ and $\theta(L)$ lie outside the unit circle and $|d| < 0{,}5$, y_t defined in terms of Equation (12) is covariance stationary and invertible. When $d > 0$, y_t has "long memory" in the sense that its autocorrelations $\rho(j)$ are not absolutely summable, i.e.

$$\sum_{j=-n}^{n} |p(j)| \text{ diverges as } n \rightarrow \infty$$

In the region $0 < d < 0{,}5$, therefore, the series is stationary and persistent, while for $0{,}5 \leq d < 1$, y_t is nonstationary as its variance is not finite, although it is still mean reverting.

To estimate the fractional differencing parameter, d, of the real interest rate differentials considered earlier, a semiparametric log periodogram regression approach proposed by Geweke and Porter-Hudak (1983), henceforth GPH, is applied. For frequencies near zero, GPH show that an estimate of d may be obtained from the OLS regression

$$\ln[I(\omega_s)] = c - d \ln[4\sin^2(\omega_s/2] + \zeta_s \qquad s = 1,..,m \tag{14}$$

where $ln[I(\omega_s)]$ is the logarithm of the periodogram of y_t computed over the harmonic frequencies

$$\omega_s = \frac{2\pi s}{T}$$

The number of harmonic ordinates to be included in the spectral regression is $m = g(T)$, where $lim_{T\to\infty} g(T) = \infty$ and $lim_{T\to\infty} g(T)/T = 0$. Setting $g(T) = T^\alpha$ with $0 < \alpha < 1$ satisfies these conditions.

A number of issues require attention in the empirical application of the GPH estimator. One such issue concerns the choice of m, which is important because the relationship underlying the GPH regression generally only holds for frequencies near zero. If too few harmonic ordinates are included, the estimation may be based on a sample which offers too few degrees of freedom. If too many are included, the estimation may be contaminated by medium and high-frequency components of the spectrum. A choice of $\alpha = 0,5$ is often employed as a rule of thumb. To evaluate the robustness of the GPH estimate of d a range of a values for α may also be used.

A second issue concerns the distribution of the GPH estimate of d. GPH proved consistency and asymptotic normality only for $d < 0$, though Robinson (1995) provided a proof for $0 < d < 0,5$. In order to ensure that stationarity and invertibility are met, the real interest rate differentials are differenced so that the resulting estimate of d (denoted $\tilde{d} = d - 1$) falls into the [-0,5; 0,5] range.

Finally, the theoretical asymptotic variance of the regression error term ζ_S, known to be $\pi^2/6$, is used here to compute the t-statistics for the null hypotheses of $\tilde{d} = 0$ $(d = 1)$ against the one-sided alternative $\tilde{d} < 0$, i.e. the tests of a unit root against a fractionally integrated alternative.

Table 5 GPH estimates of the fractional differencing parameter d

	α	d	$\tilde{d}$	Asymptotic std. error	$H_0 : \tilde{d} = 0$
SA-US	0,45	0,790	-0,210	0,219	-0,959 [0,1687]
	0,5	0,710	-0,291	0,176	-1,654 [0,0490]
	0,55	0,754	-0,246	0,146	-1,683 [0,0462]
SA-UK	0,45	0,624	-0,376	0,242	-1,554 [0,0601]
	0,5	0,608	-0,392	0,194	-2,017 [0,0218]
	0,55	0,839	-0,161	0,161	-0,996 [0,1595]
SA-Germany	0,45	0,686	-0,314	0,210	-1,498 [0,0671]
	0,5	0,872	-0,128	0,170	-0,752 [0,2259]
	0,55	0,684	-0,316	0,140	-2,250 [0,0122]
SA-Japan	0,45	0,681	-0,319	0,210	-1,521 [0,0641]
	0,5	0,739	-0,261	0,166	-1,574 [0,0577]
	0,55	0,914	-0,086	0,137	-0,622 [0,2668]
SA-Canada	0,45	0,753	-0,247	0,210	-1,178 [0,1194]
	0,5	0,822	-0,178	0,170	-1,046 [0,1479]
	0,55	0,851	-0,149	0,137	-1,081 [0,1397]

Notes

1. The GPH tests were computed in Ox using the Arfima 1.01 package developed by Doornik and Ooms (2001).
2. The probability for the test statistic of $H_0 : \tilde{d} = 0$ against $H_0 : \tilde{d} < 0$ is reported in square parentheses [ ].

The GPH estimates of d (corresponding to $d = 1 + \tilde{d}$) for the bilateral real interest rate differentials between South Africa and each of the USA, UK, Germany, Japan and Canada are reported in Table 5. Choosing $m = T^{0,45}, T^{0,5}, T^{0,55}$, these estimates of d lie between 0,608 and 0,914 (for $m = T^{0,5}$ the estimates of d are between 0,608 and 0,872). The tests of the unit root null hypothesis against a one-sided fractionally integrated alternative provide evidence that the real interest rate differential is fractionally integrated in all cases except for the SA-Canada differential (for all other differentials, 2 of the 3 tests reported reject at the 10 per cent level, i.e. the probability reported in square parentheses [ ] is < 0,1).

The evidence provided by these tests therefore supports the view that real interest rates in South Africa are linked to those in the US, UK, Germany and Japan in that the interest rate differentials with these countries are mean reverting. This is consistent with the existence of real interest parity as a long-run equilibrium condition. Since the differentials exhibit *I(d)* behaviour, however, their dynamics are persistent, and reversion to real interest parity may be rather slow.[16] It is for this reason that traditional *I(0)/I(1)* unit root tests are often unable to capture this reversion.

16 Further evidence of closer linkages over time between South African and international real interest rates was obtained from running recursive GPH estimates of d on increasing windows (samples) of the set of real interest rate differentials. Declining estimated values of d, which suggest an increase in the degree of mean reversion for the differential over time, were revealed for South Africa's differentials with the US, UK and Japan. The estimated values of d for the differentials with Germany and Canada do not appear to trend downward over time.

7. Implications and conclusions

There is no simple way of determining precisely the appropriate level of real interest rates. In an open economy they must have some reference to international levels although the evidence presented here for South Africa suggests that the links are not strong, particularly in the short run. It appears that the stance of monetary policy in South Africa has resulted in short-term real interest rates that are higher than the international average. However, the differential declined in the course of 2000, although the recent declines in official rates internationally would have reversed this trend.

From a policy perspective, the current situation cannot be seen in isolation from the current monetary policy framework and the level of the inflation rate relative to the target. A simple Taylor rule would suggest that the further the current rate is from the target (and the higher real economic activity is), the higher the real interest rate should be. When the current inflation rate exceeds the target, the nominal rate has to be raised by more than the expected acceleration in inflation in order to make the increase in the nominal interest rate equivalent to an increase in the real interest rate (subject to the degree of deviation from potential output). Countries that are at or around their inflation target can therefore have lower real rates and have more flexibility to adjust rates. It is significant for example that South Africa's real rates are similar to those of Mexico where the inflation target is still to be achieved. Therefore, although real rates have come down from the highs of 1998, current rates reflect to a certain extent the Reserve Bank's overriding commitment to the inflation target.

Finally, can the Reserve Bank reduce the cost of capital by engineering artificially low interest rates? Any attempt by the Reserve Bank to artificially reduce the cost of capital may succeed in the short run but cannot be sustained, particularly in the face of increased capital mobility. The ultimate effect of excessively low nominal interest rates is to raise inflation and long-term interest rates. The short-term benefit of low short-term real interest rates would be offset by the longer-term costs of higher inflation. The experiences of countries such as Canada, New Zealand and Australia have shown that real interest rates can be maintained at lower levels once the inflation targets have been achieved. However these countries did experience higher short-term real rates in the phase of adjustment of the inflation rate to the target.

Appendix 1: The data

Short-term and long-term real interest rates were calculated for various countries using inflation and interest rate data from the *International Financial Statistics* CD-ROM of the IMF (March, 2001). Short-term real interest rates were calculated at the annual and monthly frequencies, and long-term real interest rates were calculated at the annual frequency.

Price inflation was measured using changes in consumer price indices (CPIs) (IFS line 64). The short-term nominal interest rates were proxied using discount rates (end of period, IFS line 60) where available (money-market rates were used when this was not the case; IFS line 60b). Long-term government bonds (IFS line 61) were used for the long-term rates.

The table below provides details of the data sample periods for each country for the annual (short-term and long-term) conventional real interest rates used in Figures 2 and 3, and for monthly conventional real interest rates which are used in the empirical work in Section 6.

Table: Data sample periods

	Annual data:		Monthly data:
Country	Short-term rate	Long-term rate	Short-term rate
Australia	1970-2000	1950-2000	–
Canada	1950-2000	1950-2000	Jan 1957 – Dec 2000
Chile	1977-2000	–	–
France	1950-2000	1950-2000	–
Germany	1950-2000	1956-2000	Jan 1960 – March 2001
Japan	1950-2000	1966-2000	Jan 1957 – March 2001
Mexico	1978-2000	–	–
New Zealand	1950-2000	1950-2000	–
South Africa	1950-2000	1950-2000	Jan 1957 – March 2001
UK	1969-2000	1950-2000	Jan 1972 – Jan 2001
USA	1950-2000	1954-2000	Jan 1964 – March 2001

The following dating conventions were employed to construct the real interest rates discussed in the text: The conventional short-term (long-term) real interest rate was calculated at the annual frequency by subtracting the inflation rate in the previous year from the current annualised discount (long-term government bond) rate. At the monthly frequency, the conventional short-term real interest rate is the annualised nominal rate in the current period less the year-on-year inflation rate in the preceding period [i.e $((CPI_t - CPI_{t-12}) / CPI_{t-12}) *100$].

Ex post and *ex ante* short-term real interest rates were also calculated (Figure 1). The *ex post* short-term real interest rate at the annual frequency is the current annualised discount rate less the inflation rate realised in the subsequent year. At the monthly frequency, this rate is the annualised nominal rate in the current month less the year-on-year inflation rate realised in the subsequent period [i.e $((CPI_{t+12} - CPI_t) / CPI_t) *100$]. The *ex ante* short-term real interest rate was calculated using annual data by subtracting the annualised inflation rate expected over the subsequent year from the current annualised discount rate. As proxy for expected inflation, a Hodrick-Prescott filter was used to calculate the low frequency component of the actual year-on-year inflation series (a smoothing parameter of 100 was imposed on the annual data). As an alternative, a three-year backward-weighted average was also employed and reported in Figure 1 (inflation in the current period *t* was given a weight of 0,5, that in *t-1* a weight of 0,3, and that in *t-2* a weight of 0,2).

Appendix 2: Unit root tests

This appendix briefly sets out the two tests used in Section 6.2 of the paper. The first is the "generalised least squares" (GLS) version of the standard ADF test introduced by Elliott, Rothemberg and Stock (1996). This DF-GLS test uses the local GLS-demeaned ($DF\text{-}GLS^{\mu}$) or the local GLS-demeaned and detrended series ($DF\text{-}GLS^{\tau}$) to compute the *t*-statistic on the coefficient α ($\alpha = \rho - 1$) in the regression equation

$$\Delta \bar{y}_t = \alpha \bar{y}_{t-1} + \sum_{j=1}^{n} \phi_j \Delta\bar{y}_{t-j} + e_t \qquad \text{(A2.1)}$$

where $\bar{y}_t$ is the detrended and/or demeaned transform of y_t and e_t is white noise. With appropriate critical values, this *t*-statistic is used to test the null hypothesis of a single unit root ($\rho = 1$) against the local alternative $\bar{\rho} = 1 + \bar{c}/T$ (where *T* is the sample size, $\bar{c}$ is some constant).

The first step in calculating the DF-GLS tests is therefore to generate the series $\bar{y}_t$. Consider firstly the demeaned and detrended case. Setting $z_t = (1,t)$, β_{GLS} is estimated by GLS, i.e. from the OLS regression of $[y_1, y_2 - \bar{\alpha} y_1, \ldots, y_T - \bar{\alpha} y_{T-1}]$ onto $[z_1, z_2 - \bar{\alpha} z_1, \ldots, z_T - \bar{\alpha} z_{T-1}]$. The demeaned and detrended y_t is then calculated as

$$\bar{y}_t = y_t - z_t \bar{\beta}_{GLS} \qquad \text{(A2.2)}$$

The series y_t is demeaned in similar fashion, with the regressor *t* being excluded from z_t. Following Elliot, Rothemberg and Stock (1996), $\bar{c}$ is set equal to -7 in generating the demeaned series and equal to -13,5 in the demeaned and detrended case.

Note that the test statistic in the demeaned case has the same distribution as the ADF test with no deterministic elements included. Approximate finite sample critical values for the demeaned and detrended case are provided by Elliott, Rothemberg and Stock (1996, Table 1), whereas Cheung and Lai (1995) estimate response surfaces for the tests which provide the lag-adjusted finite sample critical values used in this study.[17]

The second test is the KPSS test of Kwiatkowski et al. (1992), which uses a parameterisation that allows a null hypothesis of stationarity to be tested. Treating the observed series y_t as the sum of a deterministic component $f(t)$, a stochastic trend r_t, and a stationary residual γ_t, the components model

$$y_t = f(t) + r_t + \gamma_t \qquad \text{(A2.3)}$$

is obtained where $f(t)$ = a constant (or a constant and a trend), $r_t = r_{t-1} + u_t$, $u_t \sim iid(0,\sigma^2_u)$, and γ_t is stationary and independent of u_t at all lags.

17 In practice, the lag order n in (A2.1) is not known, and has to be selected. This is an important decision; choosing n too small results in size distortions, but selecting n too large will decrease the power of the test as degrees of freedom are lost. Theoretical and simulation evidence suggest that the selection of the lag length n should be undertaken using pretest data-based model seletion procedures. Simulation results in Hall (1994), for example, suggest that estimating n from the data may result in a gain in power over fixing n at a relatively long length. In this study, the lag length n was selected using the information criterion proposed by Schwarz (1978). This chooses n by minimising $T \ln\tilde{\sigma}^2 + C_T$ *over a range of lag orders, where* $\tilde{\sigma}^2$ *is the maximum likelihood estimate of the variance* σ^2 *in the relevant regression equation and* C_T *equals k(lnT). All parameters in the regression equation are included in the computation of the information criterion, so k is equal to n + 1 (no deterministic component), n + 2 (demeaned test), or n + 3 (demeaned and detrended test).*

Since the stochastic trend r_t is annihilated when the variance of $u_t = 0$, and since γ_t is stationary, the null hypothesis of stationarity (trend stationarity when f(t) = a constant and a trend) is

$$H_0 : \sigma_u^2 = 0 . \tag{A2.4}$$

The KPSS test is conducted by regressing y_t on a constant (or a constant and a trend), denoting the residuals $e = [e_1 , \ldots, e_T]'$ and constructing the KPSS statistic η

$$\hat{\eta} = T^{-2} \sum_{t=1}^{T} S_t^2 / S^2 (\ell) \tag{A2.5}$$

where S_t is the partial sum

$$S_t = \sum_{j=1}^{t} e_j \tag{A2.6}$$

and $S^2(\ell)$ is a heteroscedasticity and autocorrelation consistent variance estimator given by

$$S^2(\ell) = T^{-1} \sum_{t=1}^{T} e_t^2 + 2T^{-1} \sum_{s=1}^{\ell} w(s,\ell) \sum_{t=s+1}^{T} e_t e_{t-s} . \tag{A2.7}$$

Here $w(s,\ell)$ is an optimal weighting function that corresponds to the choice of spectral window. We use a Bartlett window $w(s,\ell) = 1 - s /(\ell+1)$, as suggested by KPSS. The truncation lag ℓ was selected using the ℓ8 rule of KPSS (1992), which sets $\ell = INT\{8*(T/100)^\wedge(1/4)\}$. Critical values were taken from KPSS (1992, Table 1).

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