

**INTEREST RATE BEHAVIOUR IN A MORE
TRANSPARENT SOUTH AFRICAN MONETARY
POLICY ENVIRONMENT**

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ABSTRACT

South Africa introduced inflation targeting as a monetary policy framework in 2000. This marked a sizable shift in monetary policy management from the previous “eclectic” approach and the explicit focus on M3 money supply before that.

The study appraises the effectiveness of monetary policy under this new dispensation. However, the analysis does not centre on inflation outcomes, which can be a measure of effectiveness because they are the overriding objective of the South African Reserve Bank. In effect, it is possible to have a target-friendly inflation rate for a length of time despite monetary policy that is ambiguous and encourages unpredictability in market interest rates. However, persistent policy opaqueness can, over time, damage a favourable inflation scenario. For instance, if the public is unsure about the Reserve Bank’s desired inflation target, price setting in the wage and goods markets may eventually produce an inflation outcome that is higher than the Bank may have intended. Rather, this study adjudicates *the effectiveness of monetary policy within the context of policy transparency*, which is an intrinsic part of the inflation-targeting framework.

The study looks at the extent to which monetary policy transparency has enhanced both the anticipatory nature of the market’s response to policy actions and the force that policy has on all interest rates in the financial system, particularly long-term rates. These concepts are important because through the transmission mechanism of monetary policy, the more deft market participants are at anticipating future Reserve Bank policy the greater the Bank’s ability to steady the economy before the actual policy event.

With the aid of regression models to estimate the response of market rates to policy changes, the results show that there is significant movement in market rates in anticipation of policy action, rather than on the day of the event or the day after. Indeed, the estimates for market rates movement on the day of and even the day after the policy action are generally minute. For instance, the R157 long-term government bond yield changes by a significant 41 basis points in response to a one percentage

point change in the Reserve Bank's benchmark repo rate in the period between the last policy action and the day preceding the current action. In contrast, the R157 bond yield changes by an insignificant 2 basis points on the day of the current repo rate change and about 1 basis point the day after the current change.

The results point to a robust relationship between policy transparency and the market's ability to foresee rate action. If this were not the case, it is likely that there would be persistent market surprise and, hence, noticeable movement in interest rates on the day of the rate action and perhaps even the day after. Another important observation is that monetary policy impacts significantly on both short- and long-term market rates. Again, certifying the robustness of monetary policy under the inflation-targeting regime.

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For humankind. I have mostly known its warm side.

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CHAPTER ONE

INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

It is common for the public to assess the government on the execution of its mandate and, by extension, individual ministers on the discharge of their duties. The South African Reserve Bank, though, is rarely included in such judgement.¹ Moreover, it is about five years since the introduction of formal inflation targeting as an anchor for monetary policy in South Africa. Consequently, it is opportune to appraise the Bank on its conduct under this framework.

Notably, though, this analysis is not concerned with the level of inflation, which itself can be a test of policy success or failure because it is the overriding objective of the Reserve Bank. In fact, it is possible to have an “in-target” inflation rate for some time even though conduct of monetary policy is ambiguous and encourages volatility in market interest rates. However, persistent policy opaqueness can, over time, damage a favourable inflation scenario. For instance, if the public is unsure about the Reserve Bank’s desired inflation target, price setting in the wage and goods markets may eventually produce an inflation outcome that is higher than the Bank may have intended. Rather, this study adjudicates *the effectiveness of monetary policy within the context of policy transparency*, which is an intrinsic part of the inflation-targeting framework.

South Africa’s monetary policy framework has evolved noticeably in recent decades, and it has been the task of the Reserve Bank to craft a system that is increasingly transparent. This is particularly the case with the adoption of inflation targeting. By the nature of this framework it would be expected that surprise policy events occur infrequently, if at all.

¹ See e.g. Mail & Guardian (2004: 4-15) and The Star (2004: 16-17).

Although remarking on US policy, there is generic applicability to the comments of Poole *et al.* (2002: 85). They note that the US Federal Reserve is only able to affect longer-term rates by shaping market participants' expectations of the future Federal funds target rate, and the deeper into the future the market can predict target funds rate changes, all being equal, the greater will be the matching changes in longer-term rates. The import is that *anticipatory responses by market participants to policy events begin to steady the economy well in advance of the actual policy actions.*

It is consistent then that an understanding of Reserve Bank's reaction function is essential in the private sector's anticipation of future policy. It is likely that there will be a common mind-set between the monetary authorities and the private sector if the latter is aware of and understands the variables the Reserve Bank gauges to shape policy, and if there is certainty in the market's comprehension of the inflation-targeting specifications. That the Reserve Bank is viewed as credible is also germane. Moreover, this is relevant not just as regards the monetary policy, but expressly so in the context of the complete macroeconomy.

Lucas (1976) noted the application of rational expectations to macroeconomic models and the interdependence of policymakers and the economy. He contended that the private sector fashions expectations of the dynamic feedback rule that the authorities pursue to effect policy. "Surprise" policy events and even unforeseen inaction by the authorities is more likely when policy is opaque. In contrast, increased transparency by the authorities yields less opportunity for unanticipated intercession such as a surprise reflation stance, for instance. Poole *et al.* (2002: 66), writing on the efficient market hypothesis, note: "if markets are efficient, anticipated policy actions are already reflected in economic variables – markets respond only to unexpected policy actions".

It is against this backdrop that this study appraises the effectiveness of monetary policy in terms of the contribution of heightened policy transparency. In so doing, the study is able to judge whether the Reserve Bank is a stabilising rather than capricious force in the economy.

1.2 OBJECTIVES OF THE STUDY

It is possible to appraise the effectiveness of monetary policy and the extent of policy transparency by analysing the relationship between changes in the monetary stance and the response of market interest rates. Ideally, the increase in monetary policy transparency should reduce the element of surprise in the Reserve Bank's actions and therefore enhance the ability of market participants to *correctly anticipate* future policy events.

Consequently, this study's contribution is to assess, firstly, whether the Reserve Bank under the inflation-targeting regime has become transparent to the extent that policy actions spawn little or no interest rate volatility in the days surrounding the policy action. In other words, are Reserve Bank policy actions mostly anticipated? Or is there frequent surprise?

Second, is there a significant relationship between policy actions and the response of all market interest rates, particularly long-term rates? For monetary policy to be potent, it must impact on all market interest rates to give effect to the transmission mechanism of monetary policy. Insofar as long-term rates are influenced by expectations of future short-term rates, policy transparency will enhance the market's ability to anticipate future short-term rate action and therefore "price" long-term rates in accordance with the Reserve Bank's goals.

In terms of the methodology employed, the literature on the subject is considered to glean guidance on a framework to estimate the effectiveness of the Reserve Bank's monetary policy. In this respect, the impact of policy actions on market interest rates of various maturities is estimated over several phases. This is to ascertain the extent of anticipation in the response of the market to Reserve Bank action and the degree to which the market reacts to the actual event.

In terms of a theoretical exposition, the expectations theory of monetary policy is examined. This paradigm states that monetary policy actions shape long-term rates through their impact on current short-term rates and market participants' expectations

of future short-term rates. This exposition is relevant insofar as this study empirically tests the impact of monetary policy on long-term rates through changes in the repo rate.

The study uses both visual and empirical analysis and the sample starts with the implementation of inflation targeting in 2000 and ends after the most recent change in the Reserve Bank's repo rate in August 2004. This sample period was selected because it marks a structural break from the previous "eclectic" monetary policy framework pursued in the late 1990s and the explicit focus on M3 money supply prior to that. The inflation-targeting framework promotes increased transparency by the authorities that can alter the nature of the market's response to policy changes relative to opaque monetary policy systems.

1.3 LAYOUT OF THE STUDY

This study is cast in seven chapters and is arranged as follows: Chapter two examines the broad objectives of monetary policy and describes the evolution of policy in South Africa over the last two decades. The inflation targeting framework employed by the Reserve Bank is examined with reference to the institutional framework and the extent to which the Bank is transparent about policy.

Chapter three looks at the securities repurchase rate (repo rate) and the "transmission mechanism of monetary policy". The repo rate is the "price" at which the Reserve Bank provides liquidity to the banking system and through this process influences market interest rates with consequent impact on the economy. In other words, the Reserve Bank can tighten (an increase in the repo rate) or loosen (a reduction in the repo rate) monetary policy and the corresponding impact on market interest rates influences various economic variables, including inflation. The manner in which changes in the repo rate transmit through the economy with ultimate impact on output and inflation is called the transmission mechanism of monetary policy. Various "channels", of which five are documented, depict this mechanism. These include the interest rate channel, asset price channel, exchange rate channel, monetary and credit

aggregates channel and expectations channel. This chapter provides a comprehensive understanding of the role of monetary policy in the economy.

Armed with this knowledge, chapter four examines the literature on the impact of monetary policy on market interest rates, and also the role that market expectations of future monetary policy play in shaping interest rates. These provide frameworks to develop and contextualise the study.

Chapter five examines the correlation between the repo rate and various market interest rates of short- and long-term maturity. This serves as a precursor to more rigorous analysis in estimating the relationship between the repo rate and market interest rates.

Chapter six tests the extent of market anticipation of policy events. Regression estimates are put forth of the response of market rates to policy changes over several phases, covering anticipatory movement, movement on the day of the policy change and movement the day after the policy action. Further, the significance of the association between monetary policy actions and market interest rates across the maturity spectrum is estimated. Regression models for various short- and long-term interest rate instruments are presented.

Chapter seven concludes the study.

CHAPTER TWO

MONETARY POLICY IN SOUTH AFRICA

2.1 INTRODUCTION

It is commonly agreed that stability in the general price level is a vital prerequisite to fostering sustainable economic growth. In essence, this is the primary concern of monetary policy. However, as Van der Merwe (2004: 1) notes, economists differ on the most effective method for securing this intent.

South Africa has employed various frameworks to achieve low and stable inflation growth over the last two decades. This chapter reviews these approaches and details the purpose of monetary policy more generally.

2.2 MONETARY POLICY OBJECTIVES

Monetary policy involves the systems and measures embraced by a central bank to achieve a desired objective or set of objectives. The primary goal of monetary policy in most countries is price stability (Loayza and Schmidt-Hebbel, 2002:1). This may involve configuring monetary policy in order to achieve a specified pace of annual growth in the general price level from month to month, or an annual average rate of growth that is within a specified range.

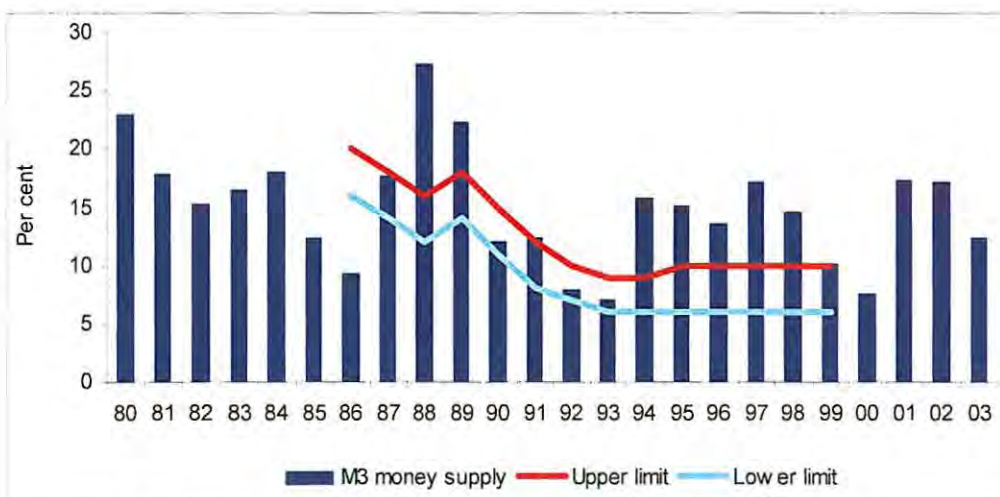
In addition to stability in the general price level, central banks' mandate may also include full employment, management of foreign exchange payments, fund raising for government and financial stability. However, the attainment of price stability is generally pre-eminent, and usually articulated in the laws governing the central bank. Such laws typically attest to the political endorsement of the importance of price stability as a means to superior long-term sustainable economic growth.

External and local forces that may derail the prescribed policy objectives shape monetary policy. Consequently, the authorities will respond to these deviations in macroeconomic variables by reorganising their policy instrument; this may be a monetary or bank credit aggregate or a short-term interest rate. In turn, these tools alter economic behaviour through a multitude of transmission mechanisms to secure the policy objectives.

2.3 MONETARY POLICY IN SOUTH AFRICA IN THE LAST TWO DECADES

In the latter part of the 1980s, South Africa's monetary policy was tied to the pace of change in domestic M3 money supply. Targets for M3 were announced for the first time in the latter part of 1985, for the period starting in the final quarter of that year. Subsequently, M3 target rates or "guidelines" were announced in the first quarter of every year until 1999 (see Figure 2.1).

Figure 2.1 M3 money supply growth in South Africa and Reserve Bank target ranges, 1980-2003



Source: South African Reserve Bank, *Quarterly Bulletin* December 2004, pg S-24; Smal and De Jager (2001: 3)

However, globally and domestically, the relationship between the growth rate of money supply and inflation had become increasingly unhinged in the 1990s, amid

liberalising financial markets and financial sector deepening. Further, the changing international environment was eroding the force of monetary policy on the general price level and this had become increasingly relevant in light of South Africa's enlarged external trade and capital orientation following the isolation during the apartheid years (Smal and De Jager, 2001: 2).

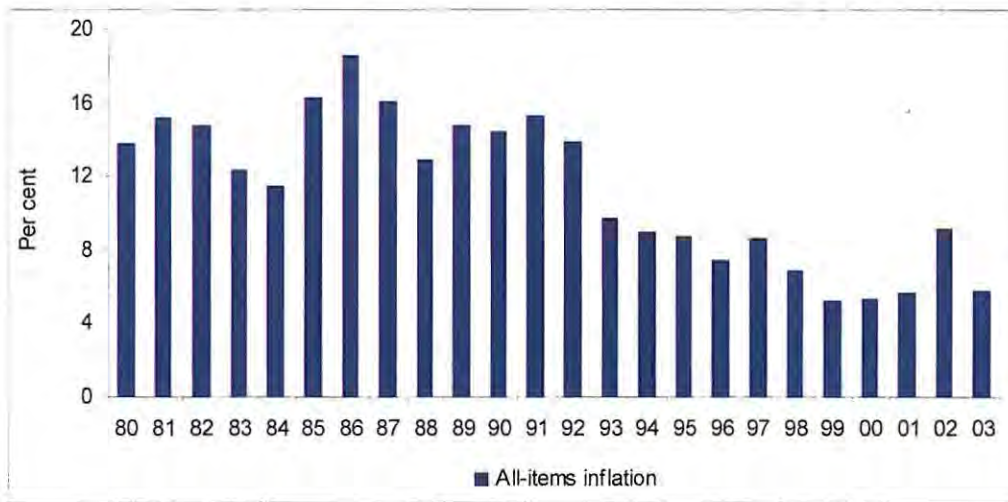
Van der Merwe (2004: 1) notes that the process of targeting money supply was a feature of informal inflation targeting, in that concerted focus was placed on achieving price stability, albeit without specific time frames. Moreover, the informal nature of this framework lay in that it constituted a transitional anchor, subsequently replaced by a broader indicator set.

With the fading relevance of broad money supply as a robust indicator of inflation, South African Reserve Bank Governor Chris Stals in 1997 specified that the Bank's inflation risk monitor would include private bank credit provision, liquidity in the banking system, the level of the yield curve, the value of the rand and official foreign reserves, and prevailing and forecast inflation (Smal and De Jager, 2001: 3). Understandably, this approach is labelled "eclectic".

Nonetheless, formal inflation targeting had become increasingly in vogue during this time, following its genesis in New Zealand in the early 1990s. Soon thereafter, Australia, Canada, Brazil, Mexico, Chile, Sweden and the United Kingdom also subscribed to this construction. South Africa officially adopted this policy framework as an anchor for monetary policy on 23 February 2000.

The shift to formal inflation targeting in South Africa did not signal the supreme failure of previous regimes. Indeed, domestic headline consumer inflation had decelerated from close to 20% in the late 1980s to single digits about a decade later (see Figure 2.2). Further, about the turn of the millennium headline consumer inflation had subsided to about 5%. In 1999, the year preceding the formal adoption of the inflation-targeting framework, headline consumer prices grew at an annual rate of 5.3%.

Figure 2.2 Headline consumer inflation (CPI) in South Africa, 1980-2003



Source: Statistics South Africa (Statistical release P0141.1)

Still, despite this achievement, Van der Merwe (2004: 1) cites four reasons for the shift to a formal inflation-targeting course:

1. On occasion, the informal targeting method fostered doubt about the Reserve Bank's monetary stance. For instance, the monetary aggregates were above proposed guidelines for protracted periods during the 1990s. Consequently, the public anticipated monetary tightening. However, this did not materialise due to the Bank's view that structural transformation in the economy was elevating the aggregates and, hence, did not warrant a conservative stance.
2. Inflation targeting allows for better synchronisation between monetary and other economic policies, so long as the target is congruent with other goals. By its very nature, the structured decision-making procedure embedded in the process promotes improved coordination. Basically, a collective "buy-in" by all stakeholders increases the framework's likelihood of success.
3. Inflation targeting allows for a more considered approach to policy and elevates the Reserve Bank's accountability. Insofar as the Bank's mandate is clear and widely understood, it is obliged to account for digression from the target and be transparent in its assessment of policy-shaping variables. The Bank, therefore, is constrained from acting beyond its mandate and will seek to inform the public about its methods.

4. Inflation targeting has the potential to shape inflation expectations. This is a function of the credibility of the framework and can bear positively on price setting in the goods and wage markets, for instance.

Mboweni (1999: 400) captured the Reserve Bank's predisposition towards inflation targeting by asserting that it "should minimise the social and economic cost of achieving price stability". Further, Van den Heever (2001: 176) noted that insofar as inflation targeting guides policies and expectations, it can lessen the "frictional costs" related to combating inflation.

2.4 INFLATION TARGETING SYSTEMS

Notably, inflation targeting is not singular in its style of execution. Carare and Stone (2003: 3-4) point to three regimes: "Full-fledged inflation targeting", "eclectic inflation targeting" and "inflation targeting lite".

Full-fledged inflation targeting encompasses an unequivocal and institutionalised commitment by the authorities to the inflation target. The transparent monetary policy process that this engenders, in turn, encourages the central bank's accountability to the target. Countries that employ this framework have a "medium to high level of credibility", and also pursue a universal approach to information in formulating policy. New Zealand was the first country to implement this regime, in 1989.

Eclectic inflation targeting allows the authorities the flexibility to pursue price stability in addition to other policy objectives, such as economic growth. This arises primarily because of the substantial credibility of its inflation record and confidence in financial stability that allows for the maintenance of price stability, even in the absence of total transparency and accountability regarding the inflation target. Carare and Stone (2003: 3) cite the European Central Bank and the United States Federal Reserve as examples of banks that pursue this framework.

Inflation targeting lite is the weakest inflation-targeting regime, and accords with a situation where the central bank has low credibility and is unable to pursue price stability as its pre-eminent goal. It usually applies to economies that have weak institutional capacity and are susceptible to economic and financial instability.

Of the three regimes listed, South Africa subscribes to the full-fledged inflation targeting model. However, even within this classification there is variation in the manner of implementation among countries pursuing this system. For instance, differences may relate to who defines the targets, their definition, the policy decision-making process, and the extent of policy transparency and accountability.

2.5 THE INSTITUTIONAL FRAMEWORK AND TARGET DESCRIPTION IN SOUTH AFRICA

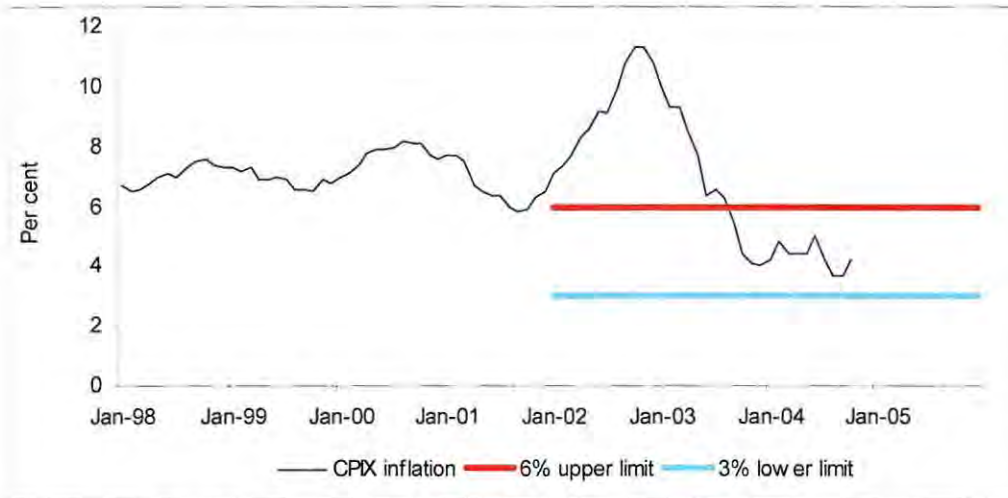
In South Africa, the Reserve Bank is an autonomous institution in terms of the Constitution where the Bank's executive management is charged with achieving its central mandate. However, the Bank consults frequently with the Minister of Finance in the context of routine safeguarding of the law.

The South African Government determines the inflation target in consultation with the Reserve Bank. However, the Bank has instrument independence in achieving its mandate. This method allows for a greater policy consistency in pursuing various objectives, such as low inflation, increased output and jobs, but also "insulates the Reserve Bank from political pressures in the pursuance of its objective of price stability" (Van der Merwe, 2004: 4).

The Reserve Bank targets a mildly altered variant of the comprehensive and publicly accepted headline consumer price index; that is, mortgage interest payments are excluded from the broad indicator. The resultant measure is labelled CPIX (see Figure 2.3). Without this exclusion, changes in the Reserve Bank's policy rate, which directly influence mortgage interest payments, will have a perverse impact on headline inflation. In other words, the Bank may wish to raise its policy rate because

of increased inflation risk, but the very act of tightening policy will itself elevate the measured rate of inflation because of the lift in mortgage interest rates.

Figure 2.3 Consumer inflation less mortgage interest rates (CPIX) and 3% to 6% inflation target range, 1998-2005



Source: Statistics South Africa (Statistical release P0141.1), South African Reserve Bank

The geographical coverage of CPIX includes the metropolitan and urban areas of South Africa. The Reserve Bank has elected to exclude rural areas from CPIX because the methodology behind its estimation does not reflect actual prices in these areas; they are calculated by applying rural expenditure pattern weights to the prices surveyed in major towns. Also, national CPIX is a relatively recent construct, which limits its usefulness.

A target *range*, as opposed to a single point or ceiling, is specified for application in South Africa. Each of these conditions has particular merits and drawbacks, and a central bank's choice ultimately reflects a trade-off.² A target range was considered most suitable for domestic application as it provides the authorities with some discretion and flexibility in the event of unanticipated price shocks (Mboweni, 1999: 407).

² See Van der Merwe (2004) and Du Plessis (2003). The latter, in particular, draws attention to the weakness in inflation targeting originating from the focus on a band rather than a point target, and also the specification of an annual average in place of a defined horizon target. Admittedly, the initial annual average specification adopted by the Reserve Bank was relinquished in November 2003, in favour of a continuous target.

In February 2000, an *annual average* rate of growth in CPIX for calendar years 2002 and 2003 within a 3% to 6% target zone was specified. The target range would then be adjusted to 3% and 5% in 2004 and 2005. This was later changed back to 3% and 6% because following the sharp devaluation in the external value of the rand in 2001 and its generally weak levels in 2002, it was evident that the target range would be missed.

A further alteration was introduced in November 2003, when a *continuous* target of 3% to 6% replaced the annual average clause. This meant that the Reserve Bank would attempt to keep the year-on-year CPIX growth rate within the 3% to 6% band in every month for the foreseeable future. The motivation for this change stemmed from the view that the original specification could spawn policy inconsistencies originating from disproportionate interest rate volatility and unsuccessful management of inflation expectations.

Van der Merwe (2004: 6) notes that the new target specification does not imply that monetary policy will always respond should inflation move out of the target range. Rather, if the breach is forecast to be only brief, policy will not react. In the instance where inflation is predicted to be out of the target range for a prolonged period, the policy stance will be altered. Essentially, the Reserve Bank's policy response, even if it is inaction, is scripted on the expected future inflation trend and not the prevailing inflation rate.

2.6 THE MONETARY POLICY COMMITTEE

The monetary policy stance is shaped by the Monetary Policy Committee (MPC), which was established prior to the implementation of inflation targeting and met for the first time on 13 October 1999. Initially, meetings were held every six to eight weeks but in early 2002 the frequency of meetings was changed to quarterly to correspond with the publication of the Reserve Bank's Quarterly Bulletin. This did not exclude the possibility of unscheduled meetings if events warranted them.

In June 2003, the frequency of MPC gatherings was again altered, allowing for a narrower interval of approximately two months; hence, the MPC now has six scheduled meetings a year. The MPC meetings, usually held over two days, involve an in-depth appraisal of numerous global and domestic variables that have a direct or even remote bearing on the domestic price level. Econometric models also aid the policy formulation. In the final analysis, though, judgement is based on all available evidence.

Van der Merwe writes (2004: 7) that while the Reserve Bank is centrally concerned with achieving the inflation target, it is sensitive to the risk that myopic focus on the target could lead to unwelcome consequences in the economy. Consequently, the MPC is not averse to showing discretion in its policy formulation if its actions can potentially foster instability amid unusual circumstances. For instance, in the event of an exogenous shock to the economy a vigorous monetary response aimed at containing inflation may engender extensive loss in output and employment. Under such conditions, the MPC would show prudence and be aware that consistent out-of-target inflation outcomes would damage the credibility of the inflation-targeting framework and, therefore, the ability to lower inflation expectations meaningfully.

The inflation-targeting framework initially incorporated an “escape clause”, which allowed for the influence of exogenous shocks that rendered attainment of the target unlikely. However, because this clause fostered ambiguity in articulating policy, it was replaced with an “explanation clause” in November 2003.³ The Reserve Bank is now obliged to disclose to the public the nature of any exogenous inflation risk and the resulting policy stance that will allow inflation to return to the target and over what horizon.

³ “Against the backdrop of reformulating the target as a continuous target, the escape clause is reformulated as an “explanation clause”. When the economy is buffeted by a supply side shock similar to those envisaged by the original escape clause that will take CPIX outside the target range (e.g. an oil price shock, a drought, a natural disaster, or a financial contagion affecting the currency), at the subsequent meeting of the Monetary Policy Committee, the Reserve Bank will inform the public of the nature of the “shock”, the anticipated impact on CPIX inflation and the monetary policy response to ensure that inflation returns to the target and the time over which this will occur” (National Treasury, 2003: 31).

2.7 POLICY TRANSPARENCY AND ACCOUNTABILITY

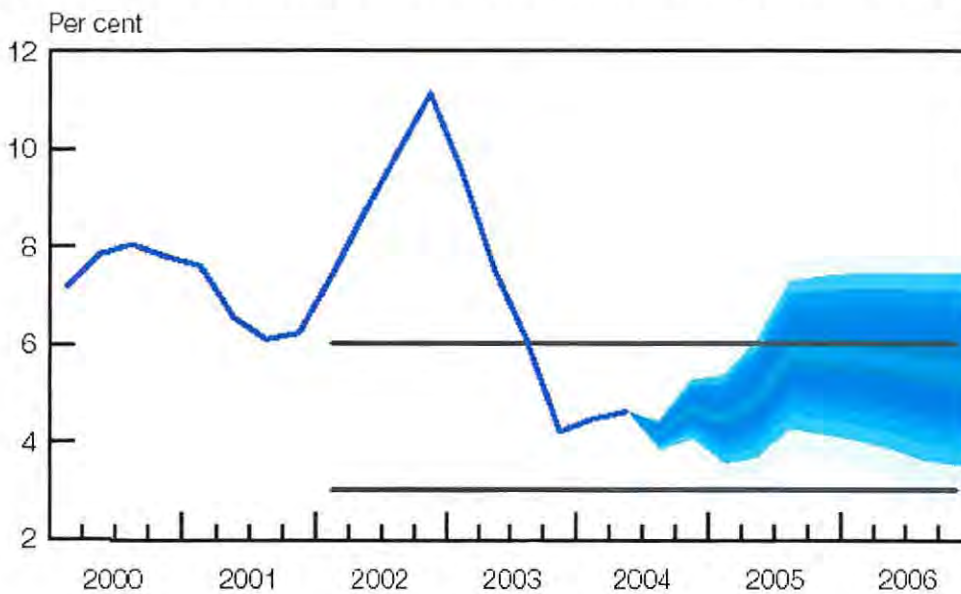
Woodford (2004: 3) notes that since the mid-1990s there has been a sharp rise in the self-awareness of central banks regarding the explicitness of their public communications about policy choices and its determinants. In this respect, inflation targeting as a monetary policy approach has proven crucial in that it proffers the central bank a platform to explain its conduct by virtue of a systematic decision-making framework.

In South Africa, the evolution to an inflation-targeting system has enhanced the transparency and accountability of monetary policymakers. Communications are frequent and take the form of published commentary as well as discussion forums where the public may engage with the authorities on issues pertaining to policy.

The *Monetary Policy Review*, published biannually, is perhaps the most comprehensive Reserve Bank publication articulating the risks to inflation and, hence, monetary policy. It includes the fan chart, which is the Reserve Bank's CPIX projection presented in the context of varying probabilities (see Figure 2.4). The fan chart comprises confidence intervals reflecting varying degrees of certainty for forecasted CPIX inflation. It is a central piece of information guiding the public on the likely course of monetary policy, although, as indicated earlier, it must be viewed alongside other data and inflation risks.

The explicit and publicly known technical specifications of the inflation-targeting framework raise the Reserve Bank's level of accountability. Moreover, the Reserve Bank is obliged to account to the Minister of Finance and Parliament on the implementation of its inflation targeting mandate. The Minister of Finance also has the power to compel the Reserve Bank to comply with the provisions of the Reserve Bank Act, should he perceive its failure to have done so.

Figure 2.4 Reserve Bank's CPIX forecast (fan chart) as at November 2004⁴



Source: South African Reserve Bank, *Monetary Policy Review November 2004*, pg 33

2.8 CONCLUSION

It is generally agreed that monetary policy is centrally concerned with the delivery of low and stable inflation. In this regard, South Africa has had laudable success over the last two decades. The adoption of inflation targeting in 2000 was a further step in employing a more robust framework to secure this end.

This chapter has highlighted the form and style of inflation targeting and the public participatory nature of the framework. The latter has lent improved transparency and accountability to monetary policy and also the ability of the public to better anticipate changes in the Reserve Bank's stance. As a result, *it would be expected* that the interest rate market would show little, if any, volatility when there is a policy change or even inaction by the Reserve Bank. This would imply that market participants have a deep and comprehensive understanding of the Reserve Bank's objectives and methods of operation.

⁴ The fan diagram employs confidence bands to illustrate varying degrees of certainty. The central and darkest band shows the most probable CPIX forecast. A slightly lighter-shaded band is added on either side of the middle band and adds an additional 10% probability to the forecast. This exercise is repeated until the entire shaded area exhibits a 90% confidence interval (South African Reserve Bank, 2001b: 33).

The following chapter discusses the role the securities repurchase rate plays in the operation of monetary policy, and also how changes in this rate impact the economy by virtue of the “transmission mechanism of monetary policy”.

CHAPTER THREE

REPO RATE AND MONETARY POLICY TRANSMISSION MECHANISM

3.1 INTRODUCTION

This chapter provides an exposition of the elements that give effect to monetary policy. These include the Reserve Bank's securities repurchase system, commonly referred to as the repo system, and the mechanism through which monetary policy is transmitted through the economy.

Reference to these subjects is important because they are essentially the vehicles that allow for the expression of monetary policy. In other words, they act as the connection between the Reserve Bank's policy choices and the resulting impact on real and financial variables in the economy.

3.2 THE REPO SYSTEM

The Reserve Bank participates in the domestic money market in order to implement the MPC's stance and to satisfy banks' liquidity requirements. In this vein, the Reserve Bank adds to the stability of the collective banking system.

The foundation of this process is that the Reserve Bank holds sway over the supply of funds in the interbank market due to its role as ultimate liquidity provider to the banking system. This occurs in that the Reserve Bank shapes the level of the interest rates at which the demand for and supply of funds is balanced. As a result, the Reserve Bank has direct influence on short-term rates in the money market and acts as

the genesis of all interest rates in the financial system. It is by this means that the Bank impacts on the economy generally and on inflation specifically.

The central carrier for the transmission of monetary policy in South Africa is the Reserve Bank's securities repurchase rate, generally called the repo rate.

3.2.1 Development of the repo system

This repo system was initiated in March 1998 by the Reserve Bank as a mechanism to generate increased flexibility in the domestic financial market adjustment process. At the time it was envisaged that liquidity provision would occur through repurchase transactions at a variable interest rate⁵ (the repo rate).

The system recognised the need that against the backdrop of the increased interconnectedness of global financial markets and heightened capital mobility, policy instruments must be able to respond speedily and delicately to underlying financial market conditions. This would allow for more effective safeguarding or restoration of equilibrium in the local market. Stals (1998: 2) noted that "interest rates, exchange rates and financial asset prices must be flexible, and must not be constrained by rigid monetary policy controls."

The Reserve Bank conceived that in contrast to the previous discount window or overnight loan facility, the repo mechanism would constantly signal the Bank's policy objectives through frequent disclosure of the amount of liquidity it was willing to make available to banking institutions daily. As a result, the system allowed for a more transparent signalling of the Reserve Bank's policy intentions to the market and thereby raised the Bank's effectiveness.

However, while the Reserve Bank intended that the market should provide daily signals about underlying liquidity conditions that would appropriately influence the

⁵ A variable rate means that the repo rate can change daily depending on the imbalance between the demand for and supply of liquidity. In this context, the repo rate can change frequently and independently of MPC meetings. A fixed rate implies that repo rate adjustments occur at the behest of the MPC and by a margin determined by the committee.

repo rate, the system proved less effective than anticipated, primarily because of inefficiencies in the interbank market. The result was that the repo rate did not always reflect market conditions and monetary policy signals sometimes appeared ambiguous.

Consequently, during 2000 and early 2001 the Reserve Bank alternated between a variable and fixed repo rate, noting that the latter resulted in greater stability in the domestic money market. On 17 March 2001, the Reserve Bank informed the private banks of its desire to formally move to a fixed repo system and, further, that it would *lower the repo rate by 100 basis points purely as a technical adjustment* to enhance the effectiveness of its accommodation system. The adjustment was effected on 6 September 2001.⁶

In June 2004, the Reserve Bank announced that it was re-examining its domestic money market operations and the functioning of the money market more generally (South African Reserve Bank, 2004a). Following discussions and a survey among participating counterparties, the Reserve Bank presented a consultation paper in December 2004, for which responses were to be lodged with the Bank by 31 January 2005.

While the Reserve Bank notes that there is no glaring weakness in monetary policy practices since the modifications effected in September 2001, more recent developments, such as the closure of the Bank's oversold foreign exchange forward book in February 2004, necessitate reassessment.⁷

⁶ For details on this and other changes to the Reserve Bank's operational procedures in the money market proposed during this time, see South African Reserve Bank (2001a).

⁷ The consultative paper explains: "For some years up until 2003, a huge structural money market surplus first needed to be drained in order to create a meaningful liquidity requirement in the domestic market. The liquidity overhang was largely associated with losses encountered (at times) on the Reserve Bank's oversold foreign exchange forward position (forward book). The subsequent expansionary impact on money market liquidity was neutralised through various so called "open market operations" namely: Reserve Bank debentures, long term reverse repo transactions, foreign exchange swaps and money market foreign exchange swaps with counter dollar deposits, which at one stage reached a level of more than R50 billion. The structural surplus has declined substantially in recent months owing mainly to: the partial settlement of the Gold and Foreign Exchange Contingency Reserve account (GFECRA) by the National Treasury; the outright selling of securities from the Reserve Bank's portfolio; as well as the recovery in the exchange rate of the rand which generated profits on the forward book. The oversold foreign exchange forward position was squared-off in February 2004 which means that the forward book will no longer be an important factor in liquidity management. In the past, it has often complicated the banks' own liquidity calculations because they

The proposed modifications are aimed at:

- streamlining the Reserve Bank's refinancing operations to render them more simple and transparent;
- raising the responsibility of banks in managing their respective liquidity requirements, and thus test their credit-worthiness in the market with regularity; and
- deepen and encourage more liquid markets through enhanced trading among money market participants. This is aimed at strengthening South Africa's financial architecture through better price discovery and competition in the money market.

3.2.2 Mechanics of the repo system

The Reserve Bank acts as banker for private banks and the repo rate is the interest rate at which the Bank lends short-term funds to the banks. The repo rate is designed to directly shape short-term money market rates and rates across the full maturity spectrum of quotes.

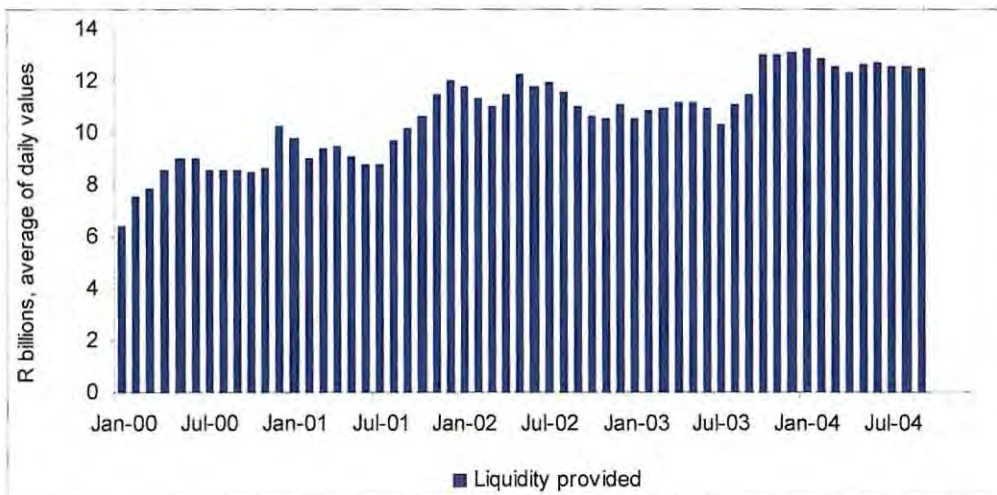
The Reserve Bank acts as lender of last resort in that it satisfies banks' daily cash shortfall or liquidity needs (South African Reserve Bank, 2004b: 2-3). A formal system, labelled the repurchase transaction system, allows banks to borrow funds from the Reserve Bank. Basically, the repo method entails the *temporary* provision of cash by the lender, in this instance the Reserve Bank, in exchange for a financial asset sold by the borrower, the bank. The transaction is impermanent in that it is subject to the borrower repurchasing the financial asset at a contracted future time, presently one week. The interest rate at which the Reserve Bank lends to the banks is the repo rate – quoted as a rate per annum – and is determined by the MPC.

could not reliably determine what amounts of liquidity would be drained by the Reserve Bank in order to sterilise the expansions related to the losses on the forward book. Having dealt with this important structural constraint, the Reserve Bank feels that it can introduce measures which it believes will encourage banks to take more responsibility for managing their own individual liquidity needs" (South African Reserve Bank, 2004a: 8-9).

The repo rate functions as the key gauge for the level of short-term market interest rates. For instance, should the Reserve Bank raise the repo rate, the cost of bank funding sourced through the repo system increases, thus eroding the existing profit margin. Banks, in turn, respond by raising their deposit and lending rates, which precipitates a collective rise in interest rates. This tempers the demand for credit-sensitive goods and services thereby lowering inflation. In all, these activities of the Reserve Bank capture the formulation and functioning of monetary policy (South African Reserve Bank, 2004b: 2-3).

It is the desire of the Reserve Bank that the repo system, and by implication the repo rate, be effective. To this end, the Bank compels the private banks to borrow a sizeable amount of liquidity from it. This is referred to as the “liquidity requirement” (see Figure 3.1).

Figure 3.1 Liquidity provided by the Reserve Bank through the main repurchase auction, 2000-2004

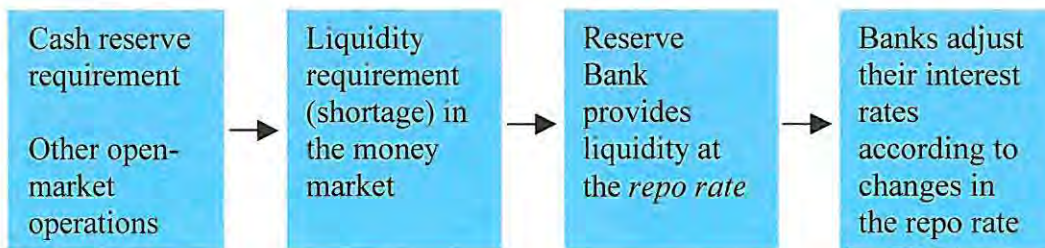


Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-26

To generate this shortage, the Reserve Bank frequently intervenes in the money market and it does this by draining excess liquidity through “open market” operations. The instruments to effect this are Reserve Bank debentures, longer-term reverse repos and foreign exchange swaps. Further, this shortage is supplemented by levying a cash

reserve requirement on banks, which is referred to as the “structural liquidity requirement”.

The Reserve Bank’s monetary policy implementation mechanism can be depicted as follows (South African Reserve Bank, 2004c: 1):



Source: South African Reserve Bank

The repo rate, through its impact on market interest rates, has a bearing on numerous real and financial variables of the economy, with consequent impact on the demand and provision of goods and services. The resulting imbalances, in turn, influence domestic inflation.

In summary, the Reserve Bank, in its role as banker to private banks, plays a central role as ultimate provider of liquidity to the financial system at the repo rate. Through this process the Bank bears directly on market interest rates.

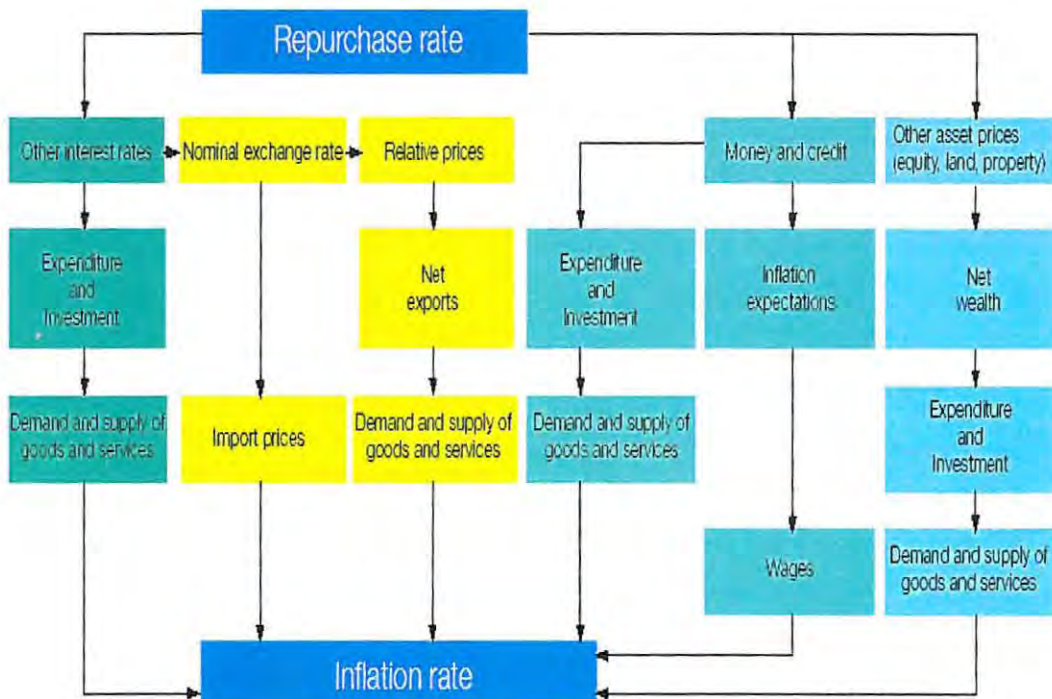
As a result, the repo rate, through its force on the full maturity spectrum of interest rates, impacts on numerous real and financial variables of the market, and ultimately on inflation. The system through which this occurs is called the monetary policy transmission mechanism, and is explained in the next section.

3.3 TRANSMISSION MECHANISM OF MONETARY POLICY

Figure 3.2 captures the essence of the monetary policy rules and relay mechanisms. Smal and De Jager (2001: 5) explain that the principal tool for monetary policy is the repo rate. This instrument impacts on the balance of demand for and supply of goods

and services in the economy through a multitude of variables or channels. These include market interest rates, exchange rates, the demand for credit, other asset prices and market participants' proclivity for spending and investment. Critically, the balance of demand relative to output capacity bears strongly on inflation, which is also shaped, among others, by forces in the labour market and import prices through the exchange rate.

Figure 3.2 Monetary policy transmission in South Africa



Source: Smal and De Jager (2001: 5)

The transmission mechanism impacts on the economy at varying speeds. The interval between the change in the repo rate and its impact on final inflation may be lengthy, and differs among countries and also, sometimes, within a single economy under changed circumstances. Smal and De Jager (2001: 6) note that that the lag between a change in central bank stance and its impact on inflation is usually between 12 and 24 months, with the complete impact occurring over at least two years. However, financial market development and external linkages may alter the transmission time.

As noted above, the transmission mechanism impacts the economy through various channels and markets. The literature shows that there are essentially five conduits of monetary policy transmission; the following exposition draws from extensively Mishkin (1995):

1. Interest rate channel
2. Asset price channel
3. Exchange rate channel
4. Monetary and credit aggregates
5. Expectations channel

In South Africa, a small open economy with a flexible exchange rate regime employing inflation targeting, the traditional interest rate and exchange rate channels are found to be the most pertinent transmission mechanisms.⁸ Nonetheless, the above five channels are briefly explained below.

3.3.1 Interest rate channel

This mechanism has been a standard feature in economics literature for more than 50 years, and is a central tenet in the basic Keynesian textbook model (Mishkin, 1995: 4).

The following illustration articulates this channel:

$$M \downarrow \Rightarrow i \uparrow \Rightarrow I \downarrow \Rightarrow Y \downarrow, \quad (3.1)$$

where M is money supply, i is the real interest rate, I is investment and Y is output.

⁸ Aron and Muellbauer (2002, in Loayza and Schmidt-Hebbel, 2002: 9-10) estimate simple structural equations to identify the primary transmission mechanism of monetary policy in South Africa. They find the interest rate and exchange rate channels to be the main transmission mechanisms of monetary policy.

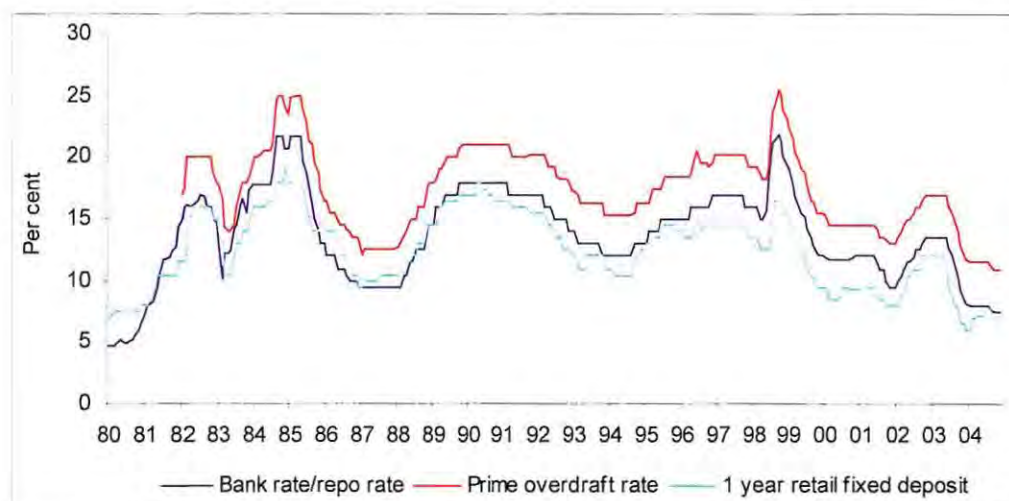
$M \downarrow$ denotes a tightening in monetary policy that encourages higher real interest rates ($i \uparrow$). In turn, the resultant increase in the cost of capital causes investment spending to decline ($I \downarrow$), leading to a decrease in aggregate demand and production ($Y \downarrow$).

The logic of this proposition is equally applicable to household spending in relation to real estate and durable goods. Expenditure on these items may be viewed as households' investment. Consequently, tight monetary policy ($M \downarrow$) fosters an increase in longer-term real interest rates ($i \uparrow$) that, in turn, curtails outlays by households on real estate and durable goods ($I \downarrow$). The resultant fall in aggregate demand ultimately impacts aggregate output ($Y \downarrow$) and prices, the latter through changes in the output gap.

It is obvious from the above that if monetary policy is to be potent, there must be a firm relationship between changes in the repo rate and the price of retail financial products. Accordingly, it is usual for South African banks to respond by adjusting their loan rates by the same amount as the adjustment in the repo rate, and with very little delay. Figure 3.3 shows a consistently firm relationship between the Reserve Bank's Bank rate/repo rate on the one hand, and the fixed deposit and prime rate on the other. It is evident that the associations are fairly strong suggesting that monetary policy has force.

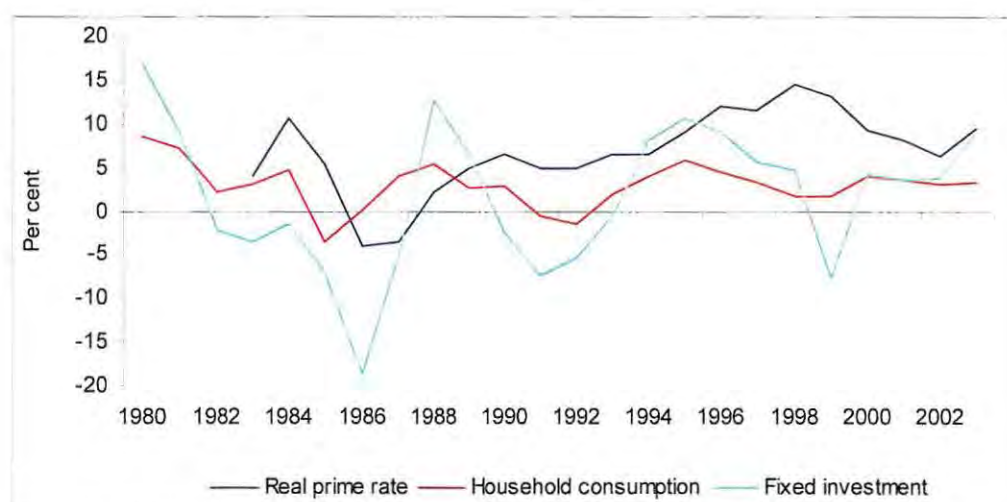
Further, the relationship between household consumption, fixed investment and the real (inflation adjusted) prime rate is exhibited in Figure 3.4. What is apparent is the sway the real prime rate has on the growth in fixed investment and households' outlays.

Figure 3.3 Nominal interest rates in South Africa, 1980-2004



Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28

Figure 3.4 Real household consumption expenditure growth, real fixed investment growth and the real prime rate (deflated using headline consumer inflation), 1980-2004



Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28 and pg S-154; Statistics South Africa (Statistical release P0141.1); author's calculations

3.3.2 Asset price channel

There are a variety of asset prices that provide channels for monetary transmission. These include stocks, bonds, real estate and foreign exchange. The latter (explained in

section 3.3.3) is grouped separately because of its extraordinary features, while the former may be suitably clustered into the asset price channel.

Monetarists argue that it is imperative to ascertain the effects of monetary policy on relative asset prices and real wealth. In this regard, Mishkin (1995: 5-6) notes two channels of monetary transmission that are deemed pertinent:

- Tobin's q theory of investment⁹; and
- the effects on consumption of changes in wealth.

Tobin describes q as firms' market value relative to the cost of replacing capital. A q value greater than 1 implies that the firm's market price exceeds the cost of replacing capital. In other words, machinery and equipment is cheap relative to the market value of the firm, and issuing expensive equity (from the buyer's perspective) to purchase cheap plant and equipment is enticing. Consequently, investment will rise as firms issue small amounts of script to accumulate large quantities of capital goods.

Tobin's q principle allows monetary policy to impact the economy through its influence on stock market prices. The monetarist view holds that a fall in money supply forces the public to reduce spending in order to shore up cash balances. Spending directed to the stock market, therefore, may be a casualty of this preference, with the result that equity prices fall.

The Keynesian slant sees a rise in interest rates as a product of tighter monetary policy, with the result that equities lose favour in place of bonds (Mishkin: 1995: 6). Consequently, equity prices decline.

Schematically, equation 3.2 shows a decline in stock prices ($P_e \downarrow$) as a result of monetary policy tightening ($M \downarrow$). This leads to a lower q ($q \downarrow$) and, in turn, lower investment ($I \downarrow$) and correspondingly output ($Y \downarrow$).

⁹ q represents the ratio of the valuation stockholders place on a firm relative to the market value of its assets. The share price reflects the shareholders' valuation, at the margin. In theory, if $q > 1$ a firm should invest. If $q < 1$ the firm should run down or sell its capital stock.

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow q \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow. \quad (3.2)$$

In regard to the wealth effect, Modigliani (1971, in Mishkin, 1995: 6) contends that equities, aside from human capital, real capital and other financial wealth, comprise a substantial portion of individuals' accumulated wealth. Thus, when stock prices decline, consumption spending, which is a function of the lifetime resources of consumers, should fall. The outcome may also be labelled a "negative wealth effect". This, of course, would be opposite to a "positive wealth effect", where a rise in stock prices and/or other financial or real wealth raises consumers' propensity to consume.

In the instance of a negative wealth shock, the mechanism of monetary policy transmission would be reflected by (equation 3.3) contractionary monetary policy ($M \downarrow$) which prompts lower stock prices ($P_e \downarrow$). The resultant slide in wealth ($W \downarrow$) spurs a drop in consumption ($C \downarrow$) and output ($Y \downarrow$).

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow W \downarrow \Rightarrow C \downarrow \Rightarrow Y \downarrow. \quad (3.3)$$

3.3.3 Exchange rate channel

This mechanism transmits through both aggregate demand (equation 3.4) and supply (equation 3.5) linkages. On the former, Obstfeld and Rogoff (1995: 75) suggest that a fall in the domestic real interest rate ($i \downarrow$), resulting from increased money supply ($M \uparrow$), causes a real depreciation of the local currency ($rand \downarrow$) through the foreign interest parity condition. This results in a rise in net exports ($NE \uparrow$) and in aggregate demand ($Y \uparrow$).

The demand leg is expressed as follows:

$$M \uparrow \Rightarrow i \downarrow \Rightarrow rand \downarrow \Rightarrow NE \uparrow \Rightarrow Y \uparrow. \quad (3.4)$$

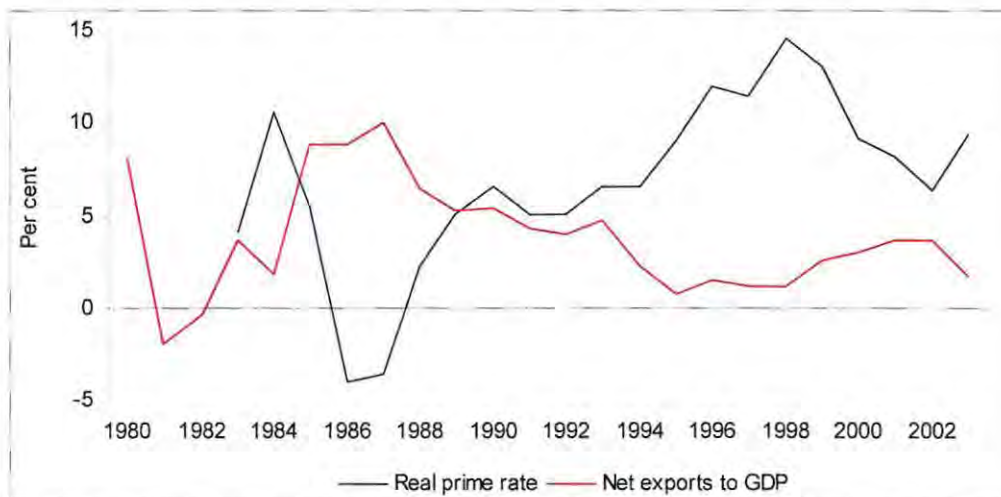
On the supply leg, the local currency's real depreciation increases import prices and, therefore, encourages inflation directly. Further, the elevated cost of imported inputs restrains aggregate supply, thereby constraining production and raising inflation.

The supply leg is depicted as follows:

$$M \uparrow \Rightarrow i \downarrow \Rightarrow rand \downarrow \Rightarrow input\ costs \uparrow \Rightarrow aggregate\ supply \downarrow \Rightarrow Y \downarrow. \quad (3.5)$$

Figure 3.5 shows the inverse relationship between the growth in net exports and the real prime rate.

Figure 3.5 Net exports as percentage of gross domestic product and the real prime rate (deflated using headline consumer inflation), 1980-2004



Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28, S-117 and S-88; Statistics South Africa (Statistical release P0141.1); author's calculations

3.3.4 Monetary and credit aggregates

Classical monetarists underscore the role of credit and (narrow and broad) monetary aggregates in determining asset, goods and factor prices (Loayza and Schmidt-Hebbel 2002: 5). These, in turn, bear on inflation.

There are essentially two conduits of monetary transmission within credit markets: the bank lending channel and balance sheet channel (Mishkin 1995: 7).

The bank lending channel stems from the special role played by banks in the financial system because of their deftness at engaging with certain types of borrowers,

principally small firms. In these circumstances the problems of asymmetric information can be especially large. In contrast, large firms have recourse to stock and bond markets and are not necessarily confined to bank intermediation. Consequently, a tightening monetary stance ($M \downarrow$) that reduces bank reserves and bank deposits (bank deposits \downarrow), impacts on loans to borrowers (bank loans \downarrow), especially those with limited or no recourse to other credit markets. This, in turn, tempers investment ($I \downarrow$) and output ($Y \downarrow$). This concept is illustrated in equation 3.6.

$$M \downarrow \Rightarrow \text{bank deposits} \downarrow \Rightarrow \text{bank loans} \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow. \quad (3.6)$$

Bernanke and Gertler (1995: 29) argue, though, that due to constant financial innovation and the diminishing role of banks in credit extension, the banks' lending role in monetary transmission is becoming less important. These authors emphasise the continued importance of the balance sheet channel as a mechanism for monetary transmission.

This channel operates through the net worth of firms, and a lower net worth translates to lower lender collateral and, therefore, higher losses from adverse selection. As a result, a decline in firms' net worth, which elevates the adverse selection problem, leads to reduced lending to facilitate investment. Also, a decline in a firm's net worth reduces the owners' equity interest, which may spur more risky investment activities. This heightens the moral hazard problem and lenders' concerns about loan repayment. Consequently, lending will be held back and investment retarded.

Monetary policy can impact firms' balance sheets in numerous ways. For instance, a tightening in policy ($M \downarrow$), which weighs on equity prices ($P_e \downarrow$), reduces firms' net worth and so leads to lower investment spending ($I \downarrow$) and aggregate demand ($Y \downarrow$) due to the heightened adverse selection and moral hazard problems. The following schematic captures this balance sheet channel:

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow \text{adverse selection} \uparrow \text{ and } \text{moral hazard} \uparrow \Rightarrow \text{lending} \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow. \quad (3.7)$$

A further example rests on contractionary monetary policy that raises real interest rates and, by virtue of reduced cash flows, reduces the health of firms' balance sheets. The following exhibit articulates this:

$$M \downarrow \Rightarrow i \uparrow \Rightarrow \text{cash flow} \downarrow \Rightarrow \text{adverse selection} \uparrow \text{ and moral hazard} \uparrow \Rightarrow \\ \text{lending} \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow. \quad (3.8)$$

3.3.5 Expectations channel

The expectations conduit entails private sector views about the future course of monetary policy and all future-related variables generally.

According to Loayza and Schmidt-Hebbel (2002: 6), all variables that encompass an intertemporal dynamic and, hence, are shaped by a vision of the future are impinged on by market participants' outlook on impending shocks and the resulting monetary policy response. The exact mechanisms for the expectations conduit are intertemporal adaptations of the static interest rate, exchange rate, asset price and money and credit channels.

3.4 CONCLUSION

The Reserve Bank, in its role as ultimate liquidity provider, uses the repo rate as its benchmark instrument for influencing market interest rates. Consequently, through an assortment of relay mechanisms referred to as the transmission mechanism of monetary policy, numerous economic variables, including inflation, are affected.

Doubts have been raised about the importance of some of the channels as meaningful transmission systems, with some commentators emphasizing some conduits and other analysts giving weight to others.¹⁰ However, this study is not concerned with adjudicating these contests. Rather, an examination of the various channels lends understanding about monetary rules and transmission mechanisms and, consequently,

¹⁰ See Mishkin (1995).

the capacity of the central bank to influence the economy through a tightening (increase in the repo rate) or loosening (lowering of the repo rate) of monetary policy.

The next section reviews the literature covering the response of market interest rates to monetary policy actions. These studies show marked variability in market rates in reaction to monetary policy events. They also show the fading effect of monetary policy changes on market rates as the maturity profile of the instrument lengthens. The expectations theory of future monetary policy is then examined to aid understanding of the actual movements in market rates.

CHAPTER FOUR

LITERATURE REVIEW AND EXPECTATIONS THEORY

4.1 INTRODUCTION

This chapter contains two key contributions to the study. First, section 4.2 documents some of the literature that comments on the impact of central bank policy on market interest rates. Also, these studies provide a framework, used in chapter six, for estimating the impact of Reserve Bank policy actions on domestic interest rates.

Second, section 4.3 introduces the role that expectations of future monetary policy plays in shaping market interest rates. This hypothesis asserts that expectations of future monetary policy can have a profound impact on market interest rates beyond the current central bank policy action.

4.2 LITERATURE REVIEW: THE RESPONSE OF MARKET INTEREST RATES TO POLICY CHANGES

There is a generous body of research documenting the impact of central bank policy on the full spectrum of interest rates in the financial system. The depth of these studies has grown as the nature of the financial markets and monetary policy itself has developed. However, many of the recent studies build on earlier work, as these remain relevant. Consequently, a mixture of older and more current sources has been considered in this study.

Cook and Hahn (1988:5) estimated the *one-day response* of bond rates to changes in the US Federal funds target rate, and ran the following regression in their event study approach:

$$\Delta R_t = b_1 + b_2 \Delta RFF_t + u_t, \quad (4.1)$$

where ΔRFF_t represents the change in the Federal funds rate target and ΔR_t the change in the bond rate on the day of the policy alteration.

Their results, for the period September 1974 through September 1979, show that changes in US Federal Reserve policy had a strong impact on the short end of the US Treasury market but markedly less on the long end. Following a one percentage point rise in the Federal funds rate target, the 3-month Treasury bill rate would increase by 50 to 55 basis points while the 20-year bond yield increased by about 10 basis points. The results were statistically significant at the 1% level in the regressions, and the size of the coefficients were fairly stable across the Treasury bill rates and then weakened steadily through the 20-year bond rate. In closing, the authors note that policy changes by the US Federal Reserve prompted sizable movement in short-term rates, moderate movement in intermediate rates and small movement in the long end of the interest rate curve (Cook and Hahn, 1998: 12).

Research by Roley and Sellon (1995: 84), covering the period October 1987 through July 1995 and utilising a similar methodology to Cook and Hahn, reveals a weaker association between variation in the Federal Reserve's benchmark rate and market interest rates. They show that on the day of a one percentage point rise in the Federal funds rate target, the 30-year Treasury bond yield rises by a mere four basis points. However, these authors found some evidence that policy changes were anticipated, in contrast to Cook and Hahn in their examination covering an earlier period.

Radecki and Reinhart (1994: 328-9) and Dale (1993, in Roley and Sellon, 1995: 87) show similarly weak results as Roley and Sellon. The former covered the US market for the period June 1989 to September 1992. Dale measured the responses of the UK market to the policy actions of the Bank of England. In both studies, long-term rates increased by a mere four to ten basis points in response to a 100 basis points increase in the policy rate in the days surrounding the policy change.

Kuttner (2000: 2) notes more sophisticated econometric work undertaken by Edelberg and Marshall (1996) to evaluate the weight of US Federal Reserve policy on the

market. Through the use of a vector autoregression (VAR) model, these authors focus on the unanticipated element of central bank actions and show a strong response from Treasury bill rates but a weak reaction from bonds rates.

Poole *et al.* (2002) considered not only the impact of policy changes on market interest rates but also *inaction* by the authorities; they analysed the degree to which the market was surprised by the US Federal Reserve not altering the funds target rate.

The authors tender evidence that the market's ability to anticipate Federal Reserve action has been greatly bolstered by the trend towards enhanced transparency.¹¹ For example, their results show that the response of the 3-month Treasury bill is nearly identical before and after the shift to increased transparency in 1994. However, the scale and significance of the response of longer-term rates declines in the post-1994 period. They explain that this may be because of increased communication by the Federal Reserve about its longer-term policy objectives. The authors also note that the market is able to anticipate policy changes further in advance because of greater transparency (Poole *et al.*, 2002: 85).

In summary, the literature provides evidence that the response of market interest rates to changes in the policy rate in the days surrounding the event grows weaker as the maturity of the interest rate instruments lengthen. However, more recent research, for instance Poole *et al.* (2002: 85), shows that along with the shift to heightened monetary policy transparency, market participants appear to be better able to foresee a shift in the central bank's stance so that the response of longer-term rates to the policy change is significant before the event but weak in the days surrounding the action. It is reasonable then to expect insignificant market response further out the yield curve on the day of the policy action if there is increasingly common mind-set between the central bank and the market, but significant response prior to the event.

The following section introduces the expectations hypothesis and shows the potential for substantial variability in market interest rates, particularly long-term instruments.

¹¹ See Poole and Rasche (2003: 1) for a chronology of the practices adopted by the US Federal Reserve since 1989.

4.3 EXPECTATIONS THEORY AND THE MONETARY TRANSMISSION MECHANISM

The inflation expectations paradigm asserts that monetary policy actions shape long-term rates through its impact on current short-term rates and the pricing of forward rates. This is linked to the idea that long-term rates equal the average of short-term rates and expected future short-term rates, and is referred to as the term structure of interest rates. According to this hypothesis, a long-term interest rate is the geometric average of the prevailing short-term rate and expected future short-term rates, which implies that rates will be priced so that an investor is indifferent between holding a long-term debt instrument and a series of short-term bonds covering the same maturity. Consequently, the volatility in the slope of the current yield curve must be systematically tied to ensuing changes in interest rates (Cook and Hahn, 1990: 1).¹²

As a result, shifting expectations about initial policy and the likelihood of policy persistence may yield varying outcomes in forward rates, with resultant variability in long-term rates. The following examples, which borrow from Roley and Sellon (1995: 78-79), lend insight to this hypothesis. The stylised model considers only the impact of current and projected policy actions on long-term rates, through their impact on forward rates, and abstracts other factors that may shape interest rates including term premia.¹³

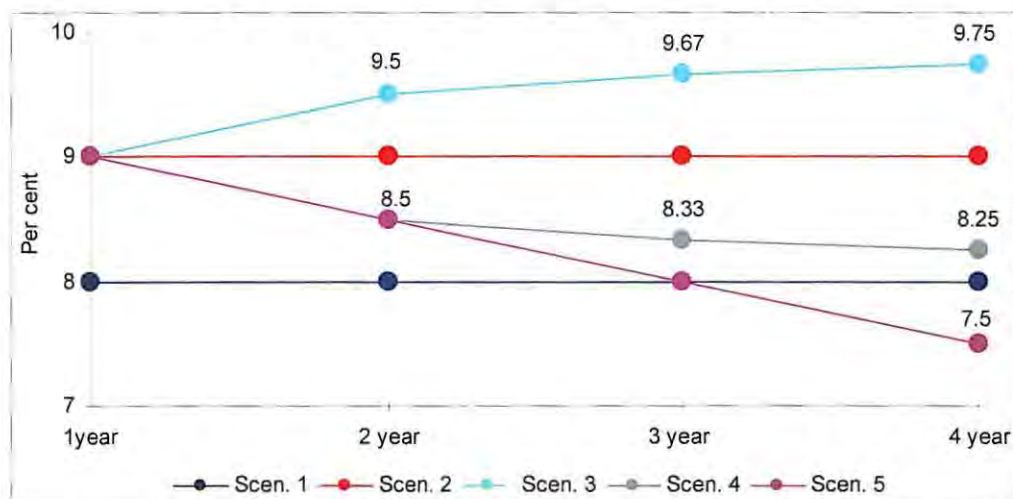
¹² The term structure of interest rates may be explained by the following example: an investor has a three-year investment horizon, and has the option of purchasing a 1-year bond now, a second 1-year bond in a year's time and a third 1-year bond in two years' time. Alternatively, the investor could purchase a 3-year bond now. In the piecemeal option, suppose that the 1-year bond is trading at an annualised yield of 7%, the 1-year bond issued in a year's time is expected to trade at 8% and the 1-year instrument issued in 2 years at 9%. Premised on the expectations theory, the yield on the 3-year bond will be 8%, the simple average of the current and anticipated future 1-year yields.

¹³ Rudebusch (1997: 3) notes that an investor contemplating a single long-term bond and a series of short-term instruments may demand a premium in the latter instance to compensate for the reinvestment risk associated with the periodic debt rollover. Consequently, a long-term bond should reflect an annualised yield that equates to the current and future short-term instruments *plus a term premium*, which may even be negative. Rudebusch highlights that an unobservable term premium that fluctuates over time complicates interpreting the term structure. This hindrance is accentuated over a longer investment horizon and the more frequent the debt rollover. Other causes for variability in longer-term interest rates may relate to changes in the liquidity premium and default risk. The former relates to the discount the buyer would seek from the seller due to the risk of low secondary market participation, for instance, while the latter relates to the credit-worthiness of the issuer. Neither of these is necessarily constant over time.

An investor has a four-year investment horizon, and the option of purchasing a 1-, 2-, 3- or 4-year asset. In this simplified illustration, the 1-year security characterizes a short-term bond, the 2- and 3-year bonds are medium-term instruments and the 4-year bond is a long-term asset.

In the first instance (scenario 1, Figure 4.1), it is assumed that there is no immediate alteration in policy and market participants expect further that policy will remain unaltered over the four-year horizon. Assuming the prevailing 1-year forward rate is 8%, the anticipated stability in policy will yield a flat term structure where forward rates of all maturities price at 8%.

Figure 4.1 Interest rate (bonds) responses to policy actions (five scenarios)



Source: Roley and Sellon (1995: 79)

Note: figures quoted are author's calculations; footnote 12 on page 37 explains the mechanics of the term structure of interest rates

Scenario 2 in Figure 4.1 assumes that monetary policy is altered by a 1 percentage point increase in the policy rate, which also raises the current 1-year rate by the same magnitude. Suppose further that market participants expect monetary policy will then remain stable over the investment horizon. As a result, in addition to the 1 percentage point rise in the current 1-year rate, the one-, two- and three-year 1-year forward rates also rise by the same quantum. In other words, the term structure of interest rates, or

the yield curve, incurs a parallel shift. This reflects expectations that the 1 percentage point increase in the policy rate will be permanent throughout the investment horizon.

Situation 3, like scenario 2, imitates a 1 percentage point rise in the policy rate with a resultant rise in the current 1-year rate. However, now investors expect that the initial policy action will be followed by a further 1 percentage point increment in the second year, after which policy will remain stable. Consequently, while the current 1-year rate increases from 8% to 9%, the three 1-year forward rates all rise to 10%. It is clear that the medium- and long-term spectrums of the yield curve rise by more than the increase in short-term rates (the policy rate and the current 1-year rate) resulting in a steepening yield curve. For clarity, the 2-year bond, at a yield of 9.5%, equals the average of the current 1-year rate (9%) and 1-year rate in one year's time (10%). The 3-year bond at 9.67% (rounded to two decimal places) equals the average of the current 1-year rate (9%), the 1-year rate in one year's time (10%) and the 1-year rate in two years' time (10%). The 4-year long-term bond yielding 9.75% equates to the average of the current 1-year rate (9%), the 1-year rate in one year's time (10%), the 1-year rate in two years' time (10%) and the 1-year rate in three years' time (10%).

Scenario 4 reflects investors' belief that the 1 percentage point increase in the policy rate will only be transitory, and the initial rate hike will be fully reversed in year two. In this instance, while the current 1-year rate rises to 9%, induced by the 1 percentage point rise in the policy rate, the three 1-year forward rates remain at 8%. From Figure 4.1 it is evident that the medium-and long-term rates follow a declining profile as maturity lengthens (negative slope), and that these yields rise less than the initial policy action. Evident also is that the elevation in the medium- and long-term rates stem entirely from the increase in the policy rate.

The fifth scenario incorporates a 1 percentage point rise in the policy rate with a corresponding increment in the current 1-year rate. Again, investors expect this to be transitory, but further believe that, subsequently, policy will be expressly relaxed: it is assumed that following the 1 percentage point increase in the current 1-year rate, the one-, two- and three-year 1-year forward rates price at 8%, 7% and 6%, respectively. The implication, manifest in Figure 4.1, is that while the current 1-year rate rises by

the full quantum of the policy action, the long-term rate in fact declines and the yield curve is strongly inverted.

4.3.1 Policy considerations

The role that expectations of future policy actions play in shaping long-term interest rates is clear from the scenarios in Figure 4.1; the following inferences can be drawn:

1. Investors' outlook on the future course of monetary policy influences the direction of long-term rates. Noticeably, the popular response of short- and long-term rates, particularly when policy action is considered persistent (scenarios 2 and 3) or even temporary (scenario 4), is positive in relation to the policy action. However, the negative response by long-term rates to an initial policy action (scenario 5) is also plausible.
2. The quantum of variability in long-term rates is related to expectations of policy persistence. Scenarios 2 (policy permanence) and 3 (several rate hikes) show how long-term rates rise by a similar or greater magnitude to the initial policy action. Scenario 4 (temporary rate action), however, reveals a more gentle response by long-term rates relative to the rise in the current 1-year rate.
3. The mixture of scenarios in Figure 4.1 show that the variability of long-term rates to changes in policy can be noticeably larger than the response of short-term securities. Expectations about the course of future policy influences short-term rates little, while its impact grows along with maturity. In the illustration, the 2-year rate rises by between 50 basis points (Scenario 4) and 150 basis points (Scenario 3), while the 4-year rate trades between a decline of 50 basis points and an increase of 175 basis points.

Given this wide berth in the response of long-term rates to policy actions, it bears strongly on the conduct of monetary policy. Moreover, should this variability be systematic and associated with the business cycle, the effectiveness of policy in influencing long-term rates will be subject to the vagaries of the business cycle.

For instance, the response of the medium- and long-term rates in scenario 3 may reflect the early stages of a business cycle upswing that is expected to foster sharply accelerating inflation and/or inflation expectations. As a result, investors expect the authorities will act resolutely to curb economic performance and so restrain inflation. The implication is that policy actions may be particularly effective in impacting on long-term rates early in the business cycle given investors' expectations of policy persistence.

Alternatively, at a more advanced stage of the business cycle market, participants may anticipate listless economic performance and a topping-out of inflation. Investors may, therefore, expect only temporary policy tightening and even policy easing following the reversal of the initial rate hikes. In this instance, short-term rates will fully reflect the temporary policy tightening while long-term rates will respond mutely, or even decline.

While the vagaries of the business cycle are highlighted as influencing monetary policy, there are other factors that can weigh on policy decisions. For example, long-term nominal rates may be shaped by real interest rates, which in turn may be influenced by fiscal policy, changes in investment and savings, and financial market deregulation. However, these and the influence on the business cycle fall beyond this study's scope.¹⁴

4.4 CONCLUSION

The literature survey highlights the waning influence of policy changes on market interest rates of longer maturity, i.e. rates further out along the yield curve. However, many studies estimated the response of market rates to policy actions only on the days surrounding the event. More recent research, however, places emphasis on the anticipatory response of the market to policy changes, and shows that the trend towards increased monetary policy transparency has enhanced the market's ability to predict policy actions.

¹⁴ For insight into the determinants of real interest rates in South Africa, see Khan and Farrell (2002).

Further, it emerges from examination of the expectations theory of monetary policy that the potential variability in interest rates (principally long-term rates) in response to a policy action can be substantial.

The expectations theory portends that the direction of long-term rates and magnitude of movement is related to investors' expectations of prospective policy interventions, and that the outcome of these expectations may yield variable patterns that can be either positive or negative. Insofar as a central bank has the capacity to influence market expectations about future policy, it is plausible to suggest that it can shape not only short-term rates but also long-term rates in a meaningful way. The Reserve Bank's increased transparency under the inflation-targeting framework implies that while long-term rates may show substantial variability, this movement may still reflect common mind-set between the Bank's view on future monetary policy and that of the interest rate market.

The following chapter examines the extent to which the repo rate influences market interest rates in South Africa. It will be apparent that the expectations hypothesis resonates strongly with observed market behaviour, and also the fading influence of the policy rate on longer-term interest rates, as noted in the literature.

CHAPTER FIVE

MONETARY POLICY ACTIONS AND MARKET INTEREST RATES IN SOUTH AFRICA

5.1 INTRODUCTION

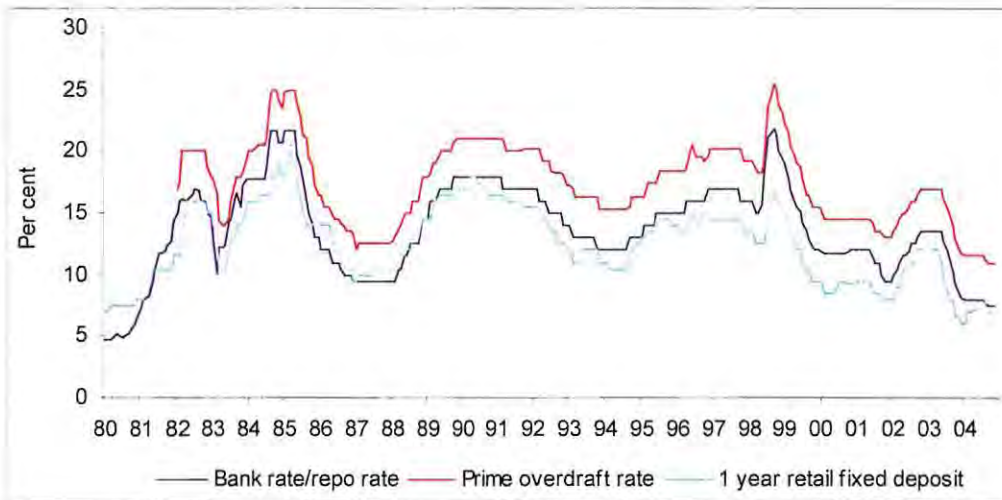
Chapter three highlighted that if monetary policy is to be potent in influencing the economy and ultimately inflation, the repo rate must have force in terms of influencing market interest rates. Movements in the latter then impact on the economy through various channels, referred to as the transmission mechanism of monetary policy.

This study has hinted at the efficacy of changes in the repo rate in influencing short-term interest rates (section 3.3.1). However, concentrating this analysis only on the short end of the interest rate curve would be incomplete. Indeed, the Reserve Bank's monetary policy actions should also have a strong influence on longer-term interest rates to be truly effective. This chapter evaluates the relationship between the Reserve Bank's repo rate and short- and long-term market interest rates.

5.2 CURRENT SHORT-TERM RATES

With reference to Figure 5.1 (a duplicate of Figure 3.3), the strength of the relationship between the Reserve Bank's repo rate and private banks' prime lending and fixed deposit rates is evident, signalling the strong impact of monetary policy on short-term rates.

Figure 5.1 Nominal interest rates in South Africa, 1980-2004



Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28

Consequently, and founded on the mechanisms of monetary transmission, if the Reserve Bank's desire is to boost or restrain aggregate output in the economy with the aim of influencing inflation, and assuming that only short-term rates matter, monetary policy is seemingly effective.

For the sake of completeness, the following schematic (a reproduction from section 3.3.1) illustrates the interest rate channel of monetary transmission:

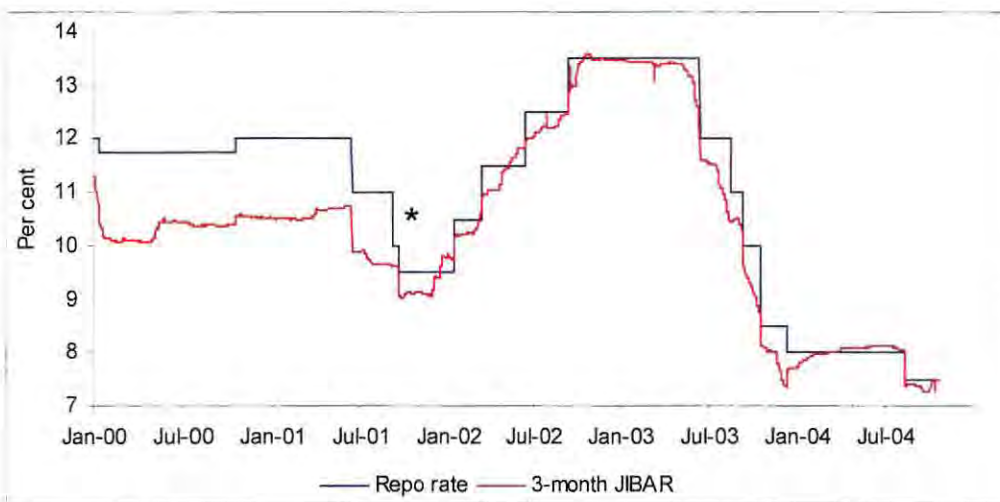
$$M \downarrow \Rightarrow i \uparrow \Rightarrow I \downarrow \Rightarrow Y \downarrow. \quad (5.1)$$

$M \downarrow$ signals contractionary monetary policy that encourages higher real interest rates ($i \uparrow$). The ensuing increase in the cost of capital weighs on investment spending ($I \downarrow$), which leads to a decline in aggregate demand and production ($Y \downarrow$). Finally, inflation is affected through changes in the output gap. This example may also be extended to household spending, with consistent conclusions.

5.3 EXTENDED SHORT-TERM (MONEY MARKET) RATES¹⁵

Testing for the efficacy of monetary policy on mildly extended short-term rates, such as the 3-month JIBAR rate, also shows a firm and positive relationship (see Figure 5.2). Further, there is a tendency for the JIBAR rate to move slightly in anticipation of changes in the repo rate.

Figure 5.2 Reserve Bank's repo rate and 3-month JIBAR interest rate, 2000-2004



(*100 basis points technical adjustment in the repo rate; not designed to influence market rates – see section 3.2.1)

Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28; Bloomberg Terminal

Somewhat longer short-term interest rates, for instance the rates on 6- and 12-month negotiable certificates of deposit (NCD), show similar directional trends to the 3-

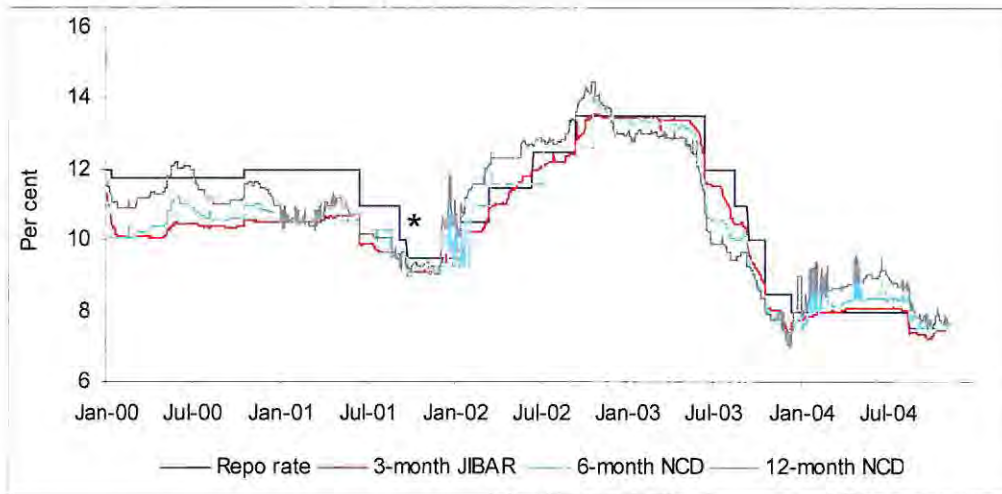
¹⁵ The 3-month JIBAR and 6- and 12-month NCD interest rates are used in this analysis because they are the most liquid debt instruments covering the short-term interest rate horizon. Also, market participants regard them as benchmarks.

The Johannesburg Interbank Agreed Rate “JIBAR” is a daily updated money market rate. Various local and international banks (currently 14) are polled daily at about 10h30 for a middle rate (the mid-point between their buy and sell rates) on their three-month deposit bankers’ acceptances (quoted as a yield). The two highest and lowest rates are eliminated from the basket, and the balance of quotes are averaged and rounded to three decimal places. The result is quoted as the three-month JIBAR and is published daily at 11h00. A bankers’ acceptance is a bill of exchange drawn on and accepted by a bank (Bond Exchange of South Africa).

A negotiable certificate of deposit (NCD) is a fixed deposit receipt issued by a bank that is negotiable in the secondary market as a financial asset. The issuer undertakes to pay the amount of the deposit plus the interest to the holder of the certificate on maturity date.

month JIBAR and repo rates (see Figure 5.3). However, it is visually apparent that the longer the instrument's maturity, the larger its movement around the repo rate; the 12-month NCD rate is noticeably more volatile than the 3-month JIBAR rate around the repo rate.

Figure 5.3 Reserve Bank's repo rate, 3-month JIBAR rate, and 6- and 12-month NCD rates, 2000-2004



(*100 basis points technical adjustment in the repo rate; not designed to influence market rates)

Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28; Bloomberg Terminal

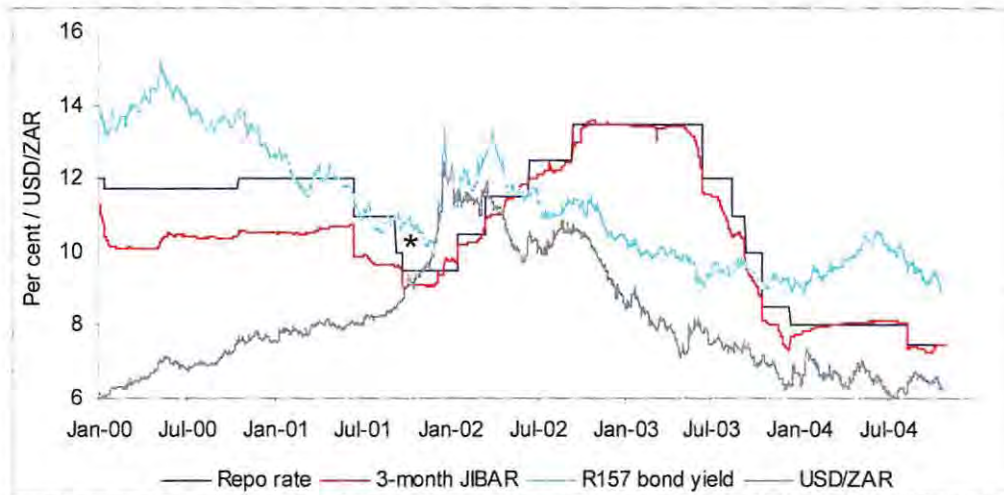
5.4 LONG-TERM (BOND) RATES

In appraising the relationship between long-term debt instruments and the repo rate, the association appears weak. For instance, the R157 government bond, which matures in September 2015, has a markedly weaker relationship than the 3-month JIBAR rate has with the repo rate (see Figure 5.4).

Conspicuously, the yield on the R157 bond rose particularly fast between December 2001 and April 2002, and quicker than both the repo and 3-month JIBAR rates. In this instance, the impulse for the movement in these rates stemmed from the sharp and broad-based depreciation in the external value of the rand, which raised inflation fears. Consequently, market participants began to price in the likelihood of a

monetary policy response. It should be noted that this is merely one illustration of market reaction to change in an inflation-determining variable. The variability in market interest rates, short- and long-term, is derived from numerous other sources, too.

Figure 5.4 Reserve Bank's repo rate, 3-month JIBAR rate, R157 long-term government bond yield and USD/ZAR exchange rate, 2000-2004



(*100 basis points technical adjustment in the repo rate; not designed to influence market rates)

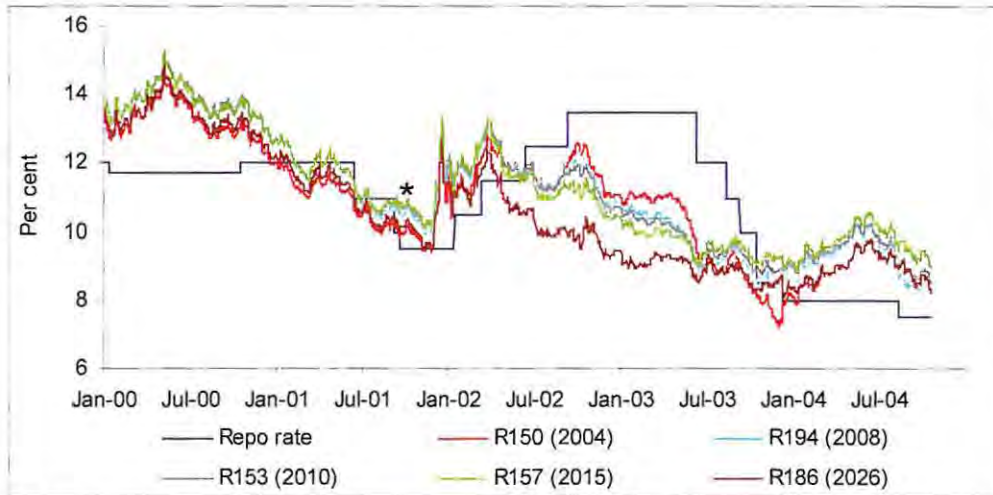
Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28; Bloomberg Terminal

Nonetheless, note that the general *decline* in the R157 bond yield from late April 2002 coincided with further *tightening* of monetary policy by the Reserve Bank. Indeed, the R157 bond yield fell by a full 400 basis points before the Reserve Bank implemented its first rate cut (100 basis points) in the cycle; the reduction was signalled to the market on 12 June 2003. The Reserve Bank then went on to lower its repo rate by a further 450 basis points over four months, with relatively mute impact on the R157 bond yield.

Further, the general directional trend of the R157 bond yield is mirrored by a variety of other bond instruments of varying maturity – short- and long-term government bonds. Figure 5.5 shows the R150 (matured February 2004), R194 (matures in February 2008), R153 (matures in August 2010) and R186 (matures in December 2026) bond yields, in addition to the R157 bond yield. The common tendency is

evident, even though there is some divergence in the extent of movement in the respective bonds' yields relative to each other. Of course, the latter translates into changes in the shape of the yield curve.

Figure 5.5 Reserve Bank's repo rate and South African government bond yields of varying maturity, 2000-2004



(*100 basis points technical adjustment in the repo rate; not designed to influence market rates)

Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28; Bloomberg Terminal

5.5 EMPIRICAL ANALYSIS

To more deeply understand the connection between monetary policy changes and market interest rates of varying maturities, an empirical examination of the contemporaneous and causal relationships between the repo rate and an assortment of short- and long-term rates is undertaken. Daily data for the period January 2000 to August 2004 is used throughout this study.

In Table 5.1, column 1 (row 1) captures the contemporaneous relationships between the repo rate and market rates as measured by their correlations. The maturity of the instruments increases from top (left) to bottom (right). It is evident that the repo rate has a strong association with short-term rates but a comparatively weaker relationship with instruments of longer maturity. For instance, the repo rate has a 98% correlation

with the 3-month JIBAR rate and a mere 9% correlation with the long-term R186 government bond.

Table 5.1 Correlation matrix

	JIBAR			NCD		R150	R194	R153	R157	R186
	REPO	3M	6M	12M						
REPO	100%	98%	95%	87%	65%	41%	33%	19%	9%	
JIBAR 3M	98%	100%	97%	92%	70%	45%	37%	22%	11%	
NCD 6M	95%	97%	100%	95%	76%	53%	46%	31%	20%	
NCD 12M	87%	92%	95%	100%	88%	71%	65%	50%	37%	
R150	65%	70%	76%	88%	100%	94%	91%	83%	74%	
R194	41%	45%	53%	71%	94%	100%	99%	95%	88%	
R153	33%	37%	46%	65%	91%	99%	100%	98%	92%	
R157	19%	22%	31%	50%	83%	95%	98%	100%	97%	
R186	9%	11%	20%	37%	74%	88%	92%	97%	100%	

There is general consistency between the findings of Granger causality tests and the correlation results, as the repo rate appears to have stronger causal relationships with instruments of short maturity than with long-term rates. Table 5.2 shows that the repo rate Granger causes most of the short-term rates (the 3- and 6-month rates, although not the 12-month rate) and the R150 government bond that matured in February 2004. Although the R150 was a bond and not a money market instrument, its result is altogether unsurprising given the closeness of its maturity relative to the sample period and also the gap between its expiry date compared with the longer-dated bonds in the sample. Also, market participants increasingly regarded the R150 bond as a money market instrument for several quarters before it matured, often trading it in a manner similar to other short-term instruments.

Table 5.2 Granger causality tests

Null Hypothesis:	F-Statistic	P-Value	Result ¹⁶
Repo does not Granger Cause 3m JIBAR	2.00	0.01	Reject Ho
Repo does not Granger Cause 6m NCD	1.79	0.04	Reject Ho
Repo does not Granger Cause 12m NCD	0.80	0.67	Do not reject Ho
Repo does not Granger Cause R150	1.65	0.06	Reject Ho
Repo does not Granger Cause R194	1.07	0.38	Do not reject Ho
Repo does not Granger Cause R153	1.13	0.32	Do not reject Ho
Repo does not Granger Cause R186	0.68	0.80	Do not reject Ho
Repo does not Granger Cause R157	0.84	0.63	Do not reject Ho

5.6 CONCLUSION

It is plain, both visually and empirically, that the relationship between the repo rate and other interest rates becomes weaker as the maturity of the debt instrument lengthens. On occasion, long-term rates even decline when the repo rate rises and monetary policy is tightened. This evidence concurs with that gleaned from the literature review and also the tenets of the expectations theory of monetary policy.

The next chapter quantifies the impact of repo rate changes on various short- and long-term interest rates in South Africa. Also, the chapter tests whether market participants anticipate policy actions as would be expected with heightened policy transparency.

¹⁶ At a 10% level of significance.

CHAPTER SIX**QUANTIFYING THE IMPACT OF MONETARY POLICY
ON INTEREST RATES IN SOUTH AFRICA****6.1 INTRODUCTION**

This study has shown that expectations of future monetary policy actions go some way towards explaining the variability in interest rates, particularly longer-term instruments. Further, it is possible for the market's response to a particular monetary policy action to be either mute or acute.

Armed with this understanding, this chapter estimates the effect of monetary policy on interest rates in South Africa. However, the methodology goes beyond merely gauging the market rates' response to policy changes in the days surrounding the event. Instead, the model centres on the anticipatory nature of the market with reference to policy actions.

6.2 THE MEASUREMENT PERIOD

It will be clear from earlier discussion (see section 4.3) that the shape of the yield curve is strongly influenced by investors' expectations of future short-term rates. Consequently, if investors anticipate the Reserve Bank's current action and do not alter their views on the future, long-term rates should respond mutely, if at all. If, however, the Reserve Bank's current action is unexpected, long-term rates may respond acutely, and the magnitude of the reaction may further be amplified if investors alter their view to reflect additional future policy action.



Notably, though, the period over which the response of long-term interest rates to policy changes is measured is essential in fully capturing its impact. For instance, long-term interest rates may respond mutely in the immediate aftermath of an anticipated policy action, even though there may have been a marked change in the long-term rate prior to the event and in expectation of the change. Consequently, only evaluating the immediate impact reflects a partial analysis and, therefore, the measurement period needs to be of sufficient length to fully capture the anticipated effects.

Roley and Sellon (1995: 82) highlight how most studies focused on the immediate movement of long-term rates in the days surrounding the policy action. However, what is evident from Figure 5.4 is that following the sharp depreciation of the rand in the final quarter of 2001 and prior to the Reserve Bank's policy intervention on 15 January, longer term rates, in this example the R157 government bond yield, rose substantially in the period late-November 2001 through January 2002. It is clear, even from mere casual observation, that only assessing the impact of the movement in the R157 on the day of the policy action and the days surrounding the event does not fully capture the market's response to the change in policy.

Nonetheless, while accepting that a longer measurement period is appropriate, identifying a correct and consistent measurement period is equally tricky. The method employed in this study follows Roley and Sellon's (1995: 81-85) analysis of the US Treasury market.

6.3 EMPIRICAL ANALYSIS

As a precursor to a more disaggregated analysis, the study separates movement in long-term interest rates into *two intervals* in an attempt to gauge the extent of *anticipatory* interest rate movement (the period starting on the day after the last change in the repo rate to the day before the current change) and the *immediate* response surrounding the policy action (the period covering the day of the current repo rate action and the day after).

The sample period starts when the Reserve Bank adopted inflation targeting in 2000, and ends after the Bank's most recent repo rate change in August 2004. The change to an inflation targeting system represented a structural break from the previous "eclectic" framework pursued during the late 1990s and the specific focus on M3 money supply before that (see chapter two). Specifically, though, the nature of the inflation targeting system expressly promotes increased transparency by the authorities and, as highlighted in the literature review, can alter the response of market interest rates to policy changes relative to opaque monetary policy frameworks.

6.3.1 Two-phase measurement period

The full sample period captures 14 events out of 30 MPC meetings where the repo rate was altered to influence market interest rates. The 100 basis points technical adjustment on 6 September 2001 is excluded from this analysis because it was not designed to impact market rates but is merely an attempt by the Reserve Bank to make the repo system more effective (see section 3.2.1).

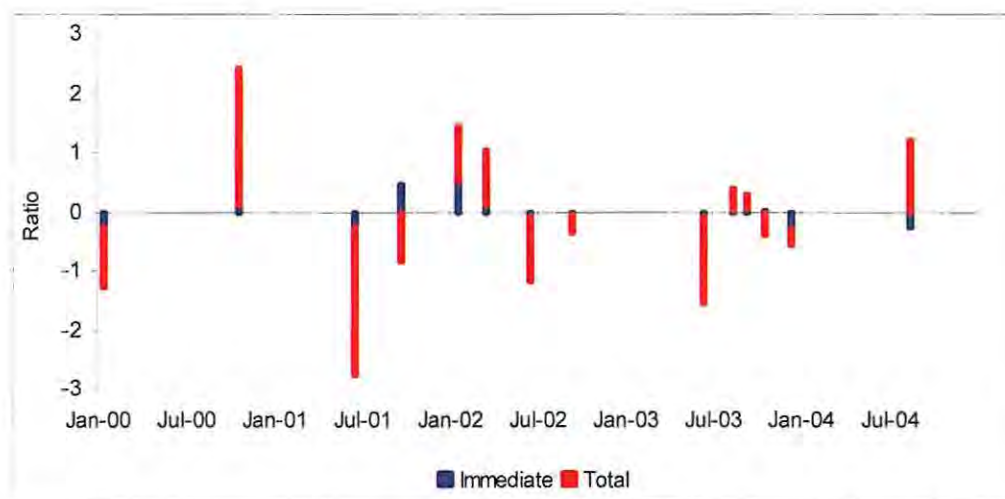
Figure 6.1 captures movements in the R157 bond yield over the period January 2000 to August 2004, measured over two different intervals:

1. the *immediate* interval represents changes in the R157 bond yield on the day of and the day after the repo rate change. In other words, the change in the bond's yield from the close on the day preceding the repo rate change to the close on the day after the change; and
2. the *total* response to a repo rate change is captured by the change in the R157 bond yield from the close on the day following the last policy change to the close on the day following the current action.

In almost every instance the immediate response is noticeably shallower compared with the total response, indicating that the change in long-term rates is largely

anticipatory – most of the change occurs between the date of the last policy change and the day prior to the current change.

Figure 6.1 Impact of policy actions on the long-term R157 government bond rate – normalised, 2000-2004

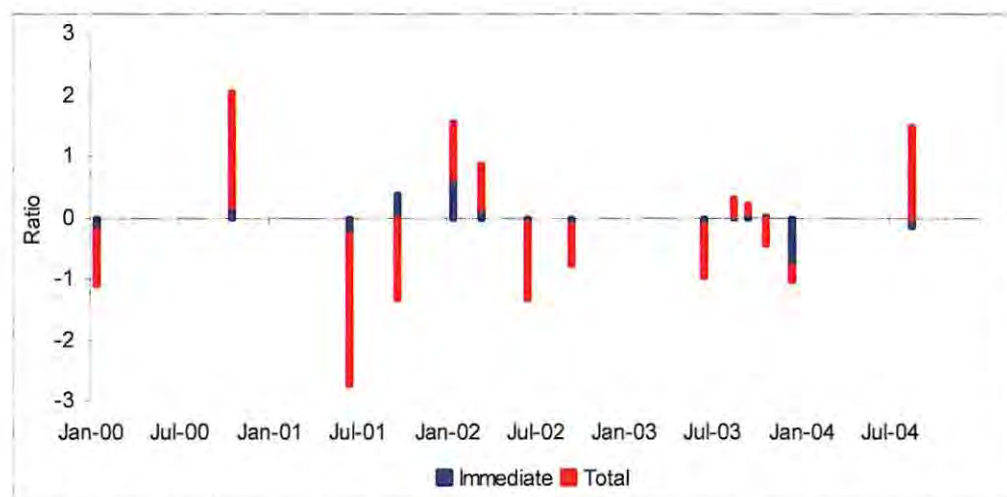


Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28; Bloomberg Terminal; author's calculations

This exercise is repeated for the R186 bond (Figure 6.2). The results concur, in that there is markedly greater movement in the R186 bond yield in a build-up to the policy event than on the day of and the day following the policy action.

It is noted that the quantum of change in the Reserve Bank's policy rate was not always consistent over the sample period. For instance, the Bank sometimes altered its policy rate by 25 basis points (twice), 50 basis points (three occasions), 100 basis points (seven times) and 150 basis points (twice). Consequently, the change in the yields of the R157 and R186 bonds, over both the narrow and wide intervals, is divided by the change in the Reserve Bank's repo rate. This normalised result implies that if the R157 bond yield in the graph rose by 1 unit, the increase perfectly matched the rise in the repo rate. Similarly, if the R157 bond yield rose by 2 units (on the graph) it means that the increase was twice as large as the Reserve Bank's repo rate action. Note, however, that the direction of movement in the R157 bond yield remains unaltered when normalising. So, it is possible for the respective bond yields to move by the same quantum as the Reserve Bank's action, but in the opposite direction.

Figure 6.2 Impact of policy actions on the long-term R186 government bond rate – normalised, 2000-2004



Source: South African Reserve Bank, *Quarterly Bulletin December 2004*, pg S-28; Bloomberg Terminal; author's calculations

6.3.2 Econometric analysis

While it is graphically evident (Figures 6.1 and 6.2) that on almost all occasions the bulk of movement in long-term interest rates occurs prior to the policy action, additional insight is to be gleaned through further decomposition of the reactions. In this regard, regression models are employed in the analysis, following the method used by Roley and Sellon (1995: 87) in their assessment of the US Treasury market.

The model is specified as follows:

$$\Delta R_{i,t} = \alpha_i + \beta_i * \Delta r_{ff,t} + e_i \quad i=1,2,3,4 \quad (6.1)$$

where α_i is the estimated constant in regression i , β_i is the estimated coefficient in regression i , and e_i is the random error term in equation i . The independent variable $\Delta r_{ff,t}$ represents the change in the Reserve Bank's repo rate and the dependent variables are:

$\Delta R_{1,t}$ = change in the market interest rate from the day following the last change in the repo rate at time t-1 to the day preceding the current repo rate change at time t. The closing rate on each relevant day is applied. This phase will be referred to as “*before*” in the text.

$\Delta R_{2,t}$ = change in the closing market interest rate on the day preceding the current repo rate change at time t to the close on day t. This phase will be referred to as “*on*” in the text.

$\Delta R_{3,t}$ = change in the market interest rate from the day of the current repo rate change at time t to the close on the following day. This phase will be referred to as “*after*” in the text.

$$\Delta R_{4,t} = \Delta R_{1,t} + \Delta R_{2,t} + \Delta R_{3,t}$$

= change in the closing market interest rate from the day following the last repo rate change at time t-1 to the close on the day subsequent to the current change at time t. This phase will be referred to as “*total*” in the text.

Table 6.1 presents the regression results summarising the relationship between changes in the repo rate and the response of the R157 bond. Admittedly, these regressions are based on a relatively small sample as the structural changes in monetary policy in South Africa prevent the use of a longer sample period. Still, the result of the relevant diagnostic tests (Table 6.2) shows that none of the standard regression assumptions have been violated, and from this perspective the results are, therefore, valid. Nevertheless, due to the limited degrees of freedom, the confidence intervals are relatively wide and caution should be exercised when interpreting and employing the results, especially where the magnitudes of the coefficients are used. However, despite the large standard errors, the results should be sufficiently robust for the purposes of this study, since the key results of interest are consistent across different interest rates. Ideally, this exercise should be repeated as more observations become available.

Table 6.1 Analysis of the relationship between the Reserve Bank's repo rate and the R157 government bond yield: Regression results

	Before	On	After	Total
$i^{17} =$	1	2	3	4
Constant (α_i)	-0.216	-0.042	0.055	-0.204
standard error	0.225	0.025	0.056	0.278
t-statistic	-0.958	-1.663	0.971	-0.735
Coefficient of	0.412**	0.023	0.058	0.494*
repo rate (β_i)				
Standard error	0.211	0.020	0.053	0.296
t-statistic	1.954	1.155	1.086	1.669
R^2	17%	4%	11%	19%
Adjusted R^2	10%	-4%	5%	12%

** significant at a 5% level.

* significant at a 10% level.

¹⁷ The notation is explained in equation 6.1.

Table 6.2 Diagnostic tests of the R157 government bond yield regressions

Regression	Test	Statistic	Conclusion ¹⁸
Before	Durbin-Watson	1.885	No serial correlation of order 1
	Breusch-Godfrey (2)	0.047	No serial correlation of order 2
	Breusch-Godfrey (3)	0.577	No serial correlation of order 3
	ARCH (1)	0.758	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	3.000	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	4.776	No ARCH-type heteroscedasticity of order 3
	White	1.128	No heteroscedasticity
On	Durbin-Watson	2.711 ¹⁹	Results are inconclusive regarding the presence of first-order serial correlation
	Breusch-Godfrey (2)	1.312	No serial correlation of order 2
	Breusch-Godfrey (3)	4.029	No serial correlation of order 3
	ARCH (1)	0.200	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.855	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	3.843	No ARCH-type heteroscedasticity of order 3
	White	3.869	No heteroscedasticity
After	Durbin-Watson	1.24	Results are inconclusive regarding the presence of first-order serial correlation ²⁰
	Breusch-Godfrey (2)	0.874	No serial correlation of order 2
	Breusch-Godfrey (3)	3.078	No serial correlation of order 3
	ARCH (1)	0.111	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.385	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.607	No ARCH-type heteroscedasticity of order 3
	White	2.039	No heteroscedasticity
Total	Durbin-Watson	1.92	No serial correlation of order 1
	Breusch-Godfrey (2)	0.002	No serial correlation of order 2
	Breusch-Godfrey (3)	1.108	No serial correlation of order 3
	ARCH (1)	1.202	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	2.250	No ARCH-type heteroscedasticity of order 2

¹⁸ At a 5% level of significance.

¹⁹ The test statistic fell in the inconclusive range of critical values for the Durbin-Watson test. However, the Breusch-Godfrey test (test statistic 0.894) does not reject the null hypothesis of no first-order serial correlation.

²⁰ The test statistic fell in the inconclusive range of critical values for the Durbin-Watson test. However, the Breusch-Godfrey test (test statistic 0.338) does not reject the null hypothesis of no first-order serial correlation.

ARCH (3)	4.370	No ARCH-type heteroscedasticity of order 3
White	0.869	No heteroscedasticity

These econometric results confirm the earlier hypothesis (see section 6.3.1) that most of the impact of changes in monetary policy occurs *before* rather than *on* or *after* the actual change in the repo rate. The coefficient of the change in repo rate is not only bigger in the *before* model (0.412) than in the *on* or *after* models (0.023 and 0.058, respectively), but is only statistically significant in the former and not the latter models. It is also significant at a 10% level in the *total* model.

The results imply that for a one percentage point change in the repo rate, the R157 bond yield will change by 0.412 percentage points *before* the actual announcement of the current repo rate change (but after the previous repo change). The R157 bond yield will change by only 0.023 percentage points and 0.058 percentage points *on* the day of and the day *after* a one percentage point change in the repo rate, respectively (although these changes are statistically insignificant). In total, the yield on the R157 bond yield changes by almost 0.5 percentage points when the repo rate changes by one percentage point.

For the conclusions reached above to be meaningful, it is crucial to verify that they are not specific to the R157 bond yield, but valid across different interest rates. The exercise is therefore repeated for several other instruments (see Table 6.3), with similar results to those for the R157 bond.

In the case of the R153 bond, for example, most of the impact of changes in monetary policy is again felt *before* rather than *on* or *after* the actual change in the repo rate. The coefficient of the change in repo is again bigger in the “before” model (0.537) than in the *on* or *after* models (0.091 and 0.004, respectively), and is only statistically significant in the former and not the latter models.²¹ The repo rate is also statistically significant in the *total* model.

²¹ At a 5% level of significance, the coefficient of the repo rate is significant only in the *before* model. However, at a 10% level of significance, it is also significant in the *on* model.

Table 6.3 Analysis of the relationship between the Reserve Bank's repo rate and market interest rates: Regression results²²

Interest rate		Before	On	After	Total
	$I^{23} =$	1	2	3	4
3-month JIBAR	β_i	0.524**	0.023**	0.372**	0.919**
	(t-statistic)	4.140	2.658	4.280	11.65
6-month NCD	β_i	0.623**	-0.055	0.266**	0.833**
	(t-statistic)	3.773	-1.030	2.517	5.118
12-month NCD	β_i	0.831**	0.126	0.203**	1.107**
	(t-statistic)	4.067	0.547	2.927	4.904
R150 ²⁴	β_i	0.560**	0.128*	0.031*	0.720**
	(t-statistic)	3.119	1.511	1.455	3.320
R153	β_i	0.537**	0.091*	0.004	0.632**
	(t-statistic)	1.960	1.656	0.156	2.086
R157	β_i	0.412**	0.023	0.058	0.494*
	(t-statistic)	1.952	1.150	1.086	1.669
R186	β_i	0.235	0.195**	0.012	0.442*
	(t-statistic)	0.937	1.996	0.284	1.544

** significant at a 5% level.

* significant at a 10% level.

The following general trends emerge from the results in Table 6.3:

- For all the market interest rates, the coefficient of the repo rate is bigger in the *before* equation than in the *on* or *after* equations. This supports the earlier hypothesis that most of the reaction in interest rates due to a change in the

²² More detailed regression results as well as the diagnostic tests of the models are presented in Appendix A.

²³ Following the notation in equation 6.1.

²⁴ Since the R150 matured in February 2004, the sample of the models involving this yield is slightly different from the others since the last policy event (in August 2004) is excluded. However, due to the prominence of this instrument during most of the sample period, it is included in the analysis.

repo rate occurs *before* the change in the monetary policy stance rather than *on* the day of the change or the day *after*.

- The coefficient of the repo rate is significant in all the *total* equations, which means that the repo rate impacts significantly on interest rates across the spectrum of maturities.
- The coefficient of the repo rate is also significant in all of the “before” equations (except the R186 bond). This means that changes in the repo rate are mostly anticipated by the market, and that interest rates across the spectrum of maturities change significantly *in anticipation* of a change in the monetary policy stance.
- From a market trader perspective, it is noteworthy that the repo rate is not statistically significant in any of the *after* equations of the long-term interest rates (except that of the R150 bond). In other words, bond yields react either before or on the day of a change in the repo rate, but not after. Moreover, the extent of the change is noticeably larger before the policy event compared with the change that occurs *on* or *after* the event, suggesting that substantially more leverage is to be had in positioning in advance of the event. This applies to all the instruments quoted except the R186 bond. This bond exhibits more or less the same coefficient *before* (0.235) and *on* (0.195) the day of the repo rate change. However, some circumspection is necessary given that the *before* result is statistically insignificant.²⁵

²⁵ While it cannot be expected that all long-term bonds behave similarly in response to repo rate changes, the R186 bond appears to exhibit unusual movement relative to both the R153 and R157 bonds. This may relate to the relative illiquidity of the R186 bond. It is widely believed that financial institutions with long-term liability streams pursue a fervent “buy and hold” strategy in the R186 bond due to the low supply of issuance by the government relative to demand. The R186 bond turned over 10.3% of its nominal outstanding issue amount in 2003 compared with 33.5% for the R153 bond and 19.9% for the R157 instrument. In 2002, the R186 bond’s turnover ratio was 17.6%, while that of the R153 bond was 30.6% and the R157 bond was 25% (National Treasury, 2004: 101). Of course, the difference in movement in the various bond yields may also have some resonance with, among others, factors such as the term premia and the varying influence of the business cycle on bond yields of different maturity.

- Except in the case of the 12-month NCD, the coefficient of the repo rate declines in the *total* column as the time to maturity increases. Therefore, the impact of the repo rate on other rates seems to decline out the yield curve, which supports the conclusions reached in chapter five.
- Insofar as most of the impact of the change in monetary policy is in anticipation of the policy event, this broadly concurs with the results of Roley and Sellon (1995: 84) in their study of the US Treasury market (noted in section 4.2). For instance, their results show that the 30-year Treasury bond yield will change by 0.2793 percentage points *before* an actual one percentage point change in the Federal funds rate target, 0.0437 percentage points *on* the day of the policy change and 0.0570 percentage points the day *after*. The *total* change amounts to 0.3799 percentage points.²⁶

6.4 CONCLUSION

This chapter has estimated the impact on various market interest rates stemming from a change in monetary policy through the repo rate. It is evident that changes in the repo rate have a significant impact on market interest rates of all maturities, although generally with fading impact as the maturity of the instrument increases.

Further, there is strong evidence that the movement in market rates is mostly in anticipation of the policy event, with comparatively modest movement on the day of or the day after a change in the repo rate.

It would be expected that with the shift to inflation targeting and particularly the increased policy transparency that this framework engenders, market participants should be better able to anticipate policy changes correctly. The evidence presented in this chapter is that the movement in market interest rates is indeed anticipatory, since most of the changes in the interest rates occur before the actual change in the repo rate. In contrast, if there was a large movement in interest rates on the day of or the

²⁶ The *before* result is significant at a 10% level while the *after* and *total* results are significant at a 5% level. The result *on* the day of the policy change is not significant.

day after a policy change, it would signal that the monetary authorities and market participants were too often not in sync. Clearly, this is not the case.

CHAPTER SEVEN

SUMMARY AND CONCLUSION

7.1 INTRODUCTION

This study has assessed the effectiveness of the Reserve Bank's monetary policy within the inflation-targeting framework that has been in employ since 2000. Specifically, the accent of the study has been on whether the shift towards increased policy transparency, which is an intrinsic feature of the Bank's inflation-targeting system, has enhanced both the anticipatory nature of the market's response to policy actions and the force that policy has on all interest rates in the financial system, particularly long-term rates.

These concepts are important because the more deft market participants are at anticipating future Reserve Bank policy, the greater the Bank's ability to steady the economy in advance of the actual policy event.

7.2 THE STUDY

The literature on the impact of monetary policy on market interest rates, which is largely of an international hue, shows that a shift towards enhanced policy transparency increases the anticipatory response of market rates to policy changes. Also, the literature shows that policy has waning influence on market rates of longer maturity, even though this may still be significant.

In South Africa, monetary policy has evolved substantially over the last two decades with specific emphasis on the shift to heightened transparency and accountability by the Reserve Bank under the inflation-targeting framework. Within this paradigm, this

study shows most of the movement in market rates occurs *in anticipation* of policy action, rather than *on* the day of the event or the day *after*. For example, the yield R157 long-term government bond changes by a significant 41 basis points in response to a one percentage point change in the Reserve Bank's benchmark repo rate in the period between the last policy action and the day preceding the current action. In contrast, the R157 bond yield changes by an insignificant 2 basis points on the day of the current repo rate change and about 1 basis point the day after the current change. The results point to a robust relationship between policy transparency and the market's ability to foresee rate action. Indeed, if this were not the case it is likely that there would be a persistence of market surprise and, hence, noticeable movement in interest rates on the day of the rate action and perhaps even the day after.

Another important observation is that changes in the Reserve Bank's monetary policy impact significantly on both short- and long-term market rates, albeit with diminishing weight further out the yield curve. Again, this certifies the robustness of domestic monetary policy.

7.3 CONCLUSION

The contribution of this study is in its appraisal of the effectiveness of monetary policy. Van der Merwe (2004: 12) writes: "the question may be asked how effective the implementation of inflation-targeting has been in South Africa. Unfortunately, there is only a relatively short period over which the performance of inflation-targeting can be evaluated."

This study accedes that the limited sample used in the analysis justifies some circumspection in the interpretation and application of its results. However, on balance, it appears that the Reserve Bank's performance in articulating monetary policy within the inflation-targeting framework is commendable. This is certified to the extent that *the preponderance of market surprise to monetary policy events, as would be evident in large movements on the day of the policy change or the day after, is rare.*

In addition, while the impact of monetary policy diminishes further out the yield curve, *the impact of policy is significant*. This implies a healthy understanding by the market of the Reserve Bank's objectives and the specifications of the inflation-targeting framework.

APPENDIX A

Table A.1 Analysis of the relationship between the 3-month JIBAR rate and the Reserve Bank's repo rate: Regression results

	Before	On	After	Total
$i^{27} =$	1	2	3	4
Constant (α_i)	0.016	-0.012	-0.055	-0.050
standard error	0.119	0.008	0.082	0.074
t-statistic	0.138	-1.462	-0.668	-0.677
Coefficient of repo rate (β_i)	0.524**	0.023**	0.372**	0.919**
Standard error	0.126	0.009	0.087	0.079
t-statistic	4.140	2.658	4.280	11.652
R^2	0.588	0.371	0.604	0.919
Adjusted R^2	0.554	0.318	0.571	0.912

** significant at a 5% level.

* significant at a 10% level.

²⁷ For the explanation of the notation, see equation 6.1.

Table A.2 Analysis of the relationship between the 6-month NCD rate and the Reserve Bank's repo rate: Regression results

	Before	On	After	Total
$i^{28} =$	1	2	3	4
Constant (α_i)	0.015	-0.078	0.040	-0.024
standard error	0.155	0.050	0.099	0.153
t-statistic	0.095	-1.553	0.402	-0.155
Coefficient of repo rate (β_i)	0.623**	-0.055	0.266**	0.834**
Standard error	0.165	0.054	0.106	0.163
t-statistic	3.773	-1.030	2.517	5.118
R ²	0.543	0.081	0.345	0.686
Adjusted R ²	0.504	0.005	0.291	0.660
** significant at a 5% level.				
* significant at a 10% level.				

Table A.3 Analysis of the relationship between the 12-month NCD rate and the Reserve Bank's repo rate: Regression results

	Before	On	After	Total
$i^{29} =$	1	2	3	4
Constant (α_i)	-0.003	-0.133	-0.008	0.019
standard error	0.192	0.217	0.065	0.212
t-statistic	-0.015	-0.612	-0.124	0.092
Coefficient of repo rate (β_i)	0.831**	0.126	0.203**	1.107**
Standard error	0.204	0.231	0.069	0.226
t-statistic	4.067	0.547	2.927	4.904
R ²	0.579	0.024	0.416	0.667
Adjusted R ²	0.544	-0.057	0.368	0.639
** significant at a 5% level.				
* significant at a 10% level.				

²⁸ For the explanation of the notation, see equation 6.1.

²⁹ For the explanation of the notation, see equation 6.1.

Table A.4 Analysis of the relationship between the R153 government bond yield and the Reserve Bank's repo rate: Regression results

	Before	On	After	Total
$i^{30} =$	1	2	3	4
Constant (α_i)	-0.241	0.019	0.013	-0.208
standard error	0.258	0.052	0.022	0.285
t-statistic	-0.933	0.367	0.612	-0.732
Coefficient of repo rate (β_i)	0.537**	0.091*	0.004	0.632**
Standard error	0.274	0.0559	0.023	0.303
t-statistic	1.960	1.656	0.156	2.086
R ²	24%	19%	0%	27%
Adjusted R ²	18%	12%	-8%	20%

** significant at a 5% level.
* significant at a 10% level.

Table A.5 Analysis of the relationship between the R186 government bond yield and the Reserve Bank's repo rate: Regression results

	Before	On	After	Total
$i^{31} =$	1	2	3	4
Constant	-0.270	0.003	-0.027	-0.294
standard error	0.236	0.092	0.039	0.269
t-statistic	-1.14	0.037	-0.70	-01.093
Coefficient of repo	0.235	0.195**	0.012	0.442*
standard error	0.251	0.098	0.041	0.286
t-statistic	0.937	1.996	0.284	1.544
R ²	7%	25%	1%	17%
Adjusted R ²	-1%	19%	-8%	10%

** significant at a 5% level.
* significant at a 10% level.

³⁰ For the explanation of the notation, see equation 6.1.

³¹ For the explanation of the notation, see equation 6.1.

Table A.6 Granger causality tests

Null Hypothesis:	F-Statistic	Probability	Result
3m JIBAR does not Granger Cause repo	4.06	0.00	Reject Ho
Repo does not Granger Cause 3m JIBAR	2.00	0.01	Reject Ho
6m NCD does not Granger Cause repo	1.96	0.02	Reject Ho
Repo does not Granger Cause 6m NCD	1.79	0.04	Reject Ho
12m NCD does not Granger Cause repo	3.10	0.00	Reject Ho
Repo does not Granger Cause 12m NCD	0.80	0.67	Do not reject Ho
R150 does not Granger Cause repo	2.99	0.00	Reject Ho
Repo does not Granger Cause R150	1.65	0.06	Reject Ho
R194 does not Granger Cause repo	2.42	0.00	Reject Ho
Repo does not Granger Cause R194	1.07	0.38	Do not reject Ho
R153 does not Granger Cause repo	2.67	0.00	Reject Ho
Repo does not Granger Cause R153	1.13	0.32	Do not reject Ho
R186 does not Granger Cause repo	1.17	0.29	Do not reject Ho
Repo does not Granger Cause R186	0.68	0.80	Do not reject Ho
R157 does not Granger Cause repo	1.13	0.33	Do not reject Ho
Repo does not Granger Cause R157	0.84	0.63	Do not reject Ho

Table A.7 Diagnostic tests of the 3-month JIBAR interest rate regressions

Regression	Test	Statistic	Conclusion ³²
Before	Durbin-Watson	2.14	No serial correlation of order 1
	Breusch-Godfrey (2)	6.851	No serial correlation of order 2
	Breusch-Godfrey (3)	6.938	No serial correlation of order 3
	ARCH (1)	1.822	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	5.812	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	5.660	No ARCH-type heteroscedasticity of order 3
	White	6.648	No heteroscedasticity
On	Durbin-Watson	1.62	No serial correlation of order 1
	Breusch-Godfrey (2)	1.770	No serial correlation of order 2
	Breusch-Godfrey (3)	5.940	No serial correlation of order 3
	ARCH (1)	0.000	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.119	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.257	No ARCH-type heteroscedasticity of order 3
	White	2.994	No heteroscedasticity
After	Durbin-Watson	1.902	No serial correlation of order 1
	Breusch-Godfrey (2)	1.134	No serial correlation of order 2
	Breusch-Godfrey (3)	1.673	No serial correlation of order 3
	ARCH (1)	0.219	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.436	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.436	No ARCH-type heteroscedasticity of order 3
	White	2.422	No heteroscedasticity
Total	Durbin-Watson	1.697	No serial correlation of order 1
	Breusch-Godfrey (2)	2.694	No serial correlation of order 2
	Breusch-Godfrey (3)	2.759	No serial correlation of order 3
	ARCH (1)	0.030	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.416	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	2.759	No ARCH-type heteroscedasticity of order 3
	White	3.855	No heteroscedasticity

³² At a 1% level of significance.

Table A.8 Diagnostic tests of the 6-month NCD interest rate regressions

Regression	Test	Statistic	Conclusion ³³
Before	Durbin-Watson	2.14	No serial correlation of order 1
	Breusch-Godfrey (2)	0.685	No serial correlation of order 2
	Breusch-Godfrey (3)	6.938	No serial correlation of order 3
	ARCH (1)	1.822	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	5.812	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	5.660	No ARCH-type heteroscedasticity of order 3
	White	0.648	No heteroscedasticity
On	Durbin-Watson	1.62	No serial correlation of order 1
	Breusch-Godfrey (2)	1.770	No serial correlation of order 2
	Breusch-Godfrey (3)	5.940	No serial correlation of order 3
	ARCH (1)	0.000	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.119	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.257	No ARCH-type heteroscedasticity of order 3
	White	2.994	No heteroscedasticity
After	Durbin-Watson	1.902	No serial correlation of order 1
	Breusch-Godfrey (2)	1.134	No serial correlation of order 2
	Breusch-Godfrey (3)	1.673	No serial correlation of order 3
	ARCH (1)	0.219	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.436	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.436	No ARCH-type heteroscedasticity of order 3
	White	2.422	No heteroscedasticity
Total	Durbin-Watson	1.697	No serial correlation of order 1
	Breusch-Godfrey (2)	2.694	No serial correlation of order 2
	Breusch-Godfrey (3)	2.759	No serial correlation of order 3
	ARCH (1)	0.030	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.416	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	2.759	No ARCH-type heteroscedasticity of order 3
	White	3.855	No heteroscedasticity

³³ At a 1% level of significance.

Table A.9 Diagnostic tests of the 12-month NCD interest rate regressions

Regression	Test	Statistic	Conclusion ³⁴
Before	Durbin-Watson	1.476	No serial correlation of order 1
	Breusch-Godfrey (2)	0.316	No serial correlation of order 2
	Breusch-Godfrey (3)	1.844	No serial correlation of order 3
	ARCH (1)	0.173	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.113	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.436	No ARCH-type heteroscedasticity of order 3
	White	1.630	No heteroscedasticity
On	Durbin-Watson	2.47	No serial correlation of order 1
	Breusch-Godfrey (2)	1.041	No serial correlation of order 2
	Breusch-Godfrey (3)	1.077	No serial correlation of order 3
	ARCH (1)	0.023	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.192	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.436	No ARCH-type heteroscedasticity of order 3
	White	1.269	No heteroscedasticity
After	Durbin-Watson	2.32	No serial correlation of order 1
	Breusch-Godfrey (2)	0.526	No serial correlation of order 2
	Breusch-Godfrey (3)	0.717	No serial correlation of order 3
	ARCH (1)	2.525	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	4.222	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	4.136	No ARCH-type heteroscedasticity of order 3
	White	1.055	No heteroscedasticity
Total	Durbin-Watson	1.348	No serial correlation of order 1
	Breusch-Godfrey (2)	0.184	No serial correlation of order 2
	Breusch-Godfrey (3)	1.901	No serial correlation of order 3
	ARCH (1)	1.086	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	1.487	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	2.327	No ARCH-type heteroscedasticity of order 3
	White	1.039	No heteroscedasticity

³⁴ At a 1% level of significance.

Table A.10 Diagnostic tests of the R153 government bond yield regressions

Regression	Test	Statistic	Conclusion ³⁵
Before	Durbin-Watson	1.985	No serial correlation of order 1
	Breusch-Godfrey (2)	0.153	No serial correlation of order 2
	Breusch-Godfrey (3)	1.000	No serial correlation of order 3
	ARCH (1)	0.313	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	1.377	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	1.822	No ARCH-type heteroscedasticity of order 3
	White	2.980	No heteroscedasticity
On	Durbin-Watson	1.743	No serial correlation of order 1
	Breusch-Godfrey (2)	1.445	No serial correlation of order 2
	Breusch-Godfrey (3)	4.767	No serial correlation of order 3
	ARCH (1)	0.261	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.346	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	0.669	No ARCH-type heteroscedasticity of order 3
	White	2.088	No heteroscedasticity
After	Durbin-Watson	1.583	No serial correlation of order 1
	Breusch-Godfrey (2)	2.274	No serial correlation of order 2
	Breusch-Godfrey (3)	4.635	No serial correlation of order 3
	ARCH (1)	1.073	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.867	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	1.284	No ARCH-type heteroscedasticity of order 3
	White	0.634	No heteroscedasticity
Total	Durbin-Watson	1.884	No serial correlation of order 1
	Breusch-Godfrey (2)	0.044	No serial correlation of order 2
	Breusch-Godfrey (3)	1.353	No serial correlation of order 3
	ARCH (1)	0.451	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.773	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	1.779	No ARCH-type heteroscedasticity of order 3
	White	2.414	No heteroscedasticity

³⁵ At a 1% level of significance.

Table A.11 Diagnostic tests of the R186 government bond yield regressions

Regression	Test	Statistic	Conclusion
Before	Durbin-Watson	1.710	No serial correlation of order 1
	Breusch-Godfrey (2)	0.353	No serial correlation of order 2
	Breusch-Godfrey (3)	0.450	No serial correlation of order 3
	ARCH (1)	0.253	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.778	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	3.892	No ARCH-type heteroscedasticity of order 3
	White	0.372	No heteroscedasticity
On	Durbin-Watson	2.18	No serial correlation of order 1
	Breusch-Godfrey (2)	2.040	No serial correlation of order 2
	Breusch-Godfrey (3)	9.526	No serial correlation of order 3
	ARCH (1)	0.094	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.463	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	1.102	No ARCH-type heteroscedasticity of order 3
	White	5.215	No heteroscedasticity
After	Durbin-Watson	2.46	Results are inconclusive regarding first-order serial correlation ³⁶
	Breusch-Godfrey (2)	2.214	No serial correlation of order 2
	Breusch-Godfrey (3)	2.351	No serial correlation of order 3
	ARCH (1)	0.025	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	0.870	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	1.964	No ARCH-type heteroscedasticity of order 3
	White	0.998	No heteroscedasticity
Total	Durbin-Watson	1.845	No serial correlation of order 1
	Breusch-Godfrey (2)	2.558	No serial correlation of order 2
	Breusch-Godfrey (3)	3.041	No serial correlation of order 3
	ARCH (1)	1.591	No ARCH-type heteroscedasticity of order 1
	ARCH (2)	4.386	No ARCH-type heteroscedasticity of order 2
	ARCH (3)	6.784	No ARCH-type heteroscedasticity of order 3
	White	0.014	No heteroscedasticity

³⁶ The Durbin-Watson test statistic fell in the inconclusive range of values. However, the Breusch-Godfrey test (with a test statistic of 0.851) does not reject the null hypothesis of no first-order serial correlation.

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