The transmission of monetary policy under the repo system in South Africa: An empirical analysis[♣]

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Abstract

The study examines the influence of the repo rate on the interbank rate, as well as analyse whether the transmission channels of interest rates have changed since the adjustment to the repo system in September 2001. The paper employs the Granger causality test using the ECM framework. The results suggest that the influence of the repo rate on the interbank rate tended to be stronger before the adjustments to the system were made. In addition, the interbank rate and the repo rate were found to "reverse" roles in the period after the adjustments to the system. Moreover, and surprisingly, our results show that the changes to the repo system in 2001 did not lead to the achievement of the intended transmission channel; instead it was found that the system in place before the changes were made was in fact already achieving the transmission path that the authorities hoped to accomplish by changing the system.

Key Words: ECM, Causality test, Monetary transmission, Repo system

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1. Introduction

A major concern of the monetary authorities in South Africa is how to improve the functioning of the money market in order to strengthen the implementation of monetary policy. The monetary policy framework currently implemented by the South African Reserve Bank (SARB) is an inflation-targeting framework, which was formally adopted on 6 April 2000 (Mboweni, 2000a:1). It provides for an explicit inflation target to be set and the responsibility of achieving this target is given to the Reserve Bank (Plenderleith, 2003:3). The main instrument that is used by the SARB to target inflation is the repo rate. The repo rate is the rate that the SARB charges for borrowed cash reserves and it is the most significant rate in the financial markets.

In order to ensure that the repo rate is made effective, the SARB makes sure that the private sector banks are indebted to it at all times (Faure, 2004:67). It does this by creating a "money market shortage", which it then refinances at the repo rate. Banks in need of liquidity sell assets under repo to the Reserve Bank in exchange for borrowed cash reserves and pay the repo rate for this accommodation. This process takes place in the interbank market. This market is essentially the foundation of monetary policy and its transmission through the financial system, yet its operation and its significance in the implementation of monetary policy are not always well understood.

The importance of the interbank market in the transmission of monetary policy is evident in the fact that the SARB made adjustments to the 1998 refinancing system for the main reason that it "did not have the capability to address certain issues hampering the effective functioning of the interbank market" (SARB, 2001a:3). An effective interbank market should respond immediately to changes in the repo rate and will as a result ensure effective pricing in the money market as a whole (SARB, 2001a:4). Thus, certain changes were made to the 1998 refinancing system with the intention of improving the functioning of the interbank market and hence the implementation of monetary policy. According to the Reserve Bank, "effective monetary policy implementation implies … that the central bank should manage liquidity in such a manner that the interbank overnight rate stays near (generally slightly below) the level of the repo rate" (SARB, 2001a:5). In addition, Gidlow (2001:3) states that the monetary authorities take the view that the money market would function more efficiently if changes to the repo rate had a more direct effect on the interbank rate. That is, changes in monetary policy should first affect the interbank rates, which then transmit a similar effect to other money market rates and finally impact on the interest rates in the economy.

However, before the adjustments to the repo system in September 2001, the opposite mechanism tended to be in operation (Gidlow, 2001:3). This paper is therefore aimed at determining whether the change to the repo system in 2001 has had a more direct influence with concomitantly stronger impact on the interbank rate through to the other interest rates. The paper also examined whether the transmission paths of the monetary policy have changed following the adjustment to the repo system. The current study focuses on the period before the change to the repo system (i.e. March 1998 to September 2001) and the period after the change (i.e. September 2001 to November 2004).

The remainder of the paper is organised as follows: section 2 highlights the previous monetary policy regimes in South Africa and illustrates the importance of the interbank market in monetary transmission. Section 3 reviews the overall monetary transmission mechanism with the main focus being on the transmission path from the official interest rate to other interest rates in the economy. Section 4 outlines the analytical framework and discusses the econometric techniques used. Section 5 presents and discusses the results and section 6 concludes the study.

2. Money market operation and monetary policy in South Africa

The interbank market plays a pivotal role in the implementation of monetary policy, because interbank and other money-market rates should be sensitive to any changes in the Reserve Bank's repo rate. That is, the interbank and money market rates should respond immediately to adjustments in the repo rate. Thus, an effective interbank market will ensure that changes in the refinancing rates of the SARB will be quickly transmitted to other money market rates and thereby ensure effective pricing in the money market as a whole (Gidlow, 2001:2).

According to Gidlow (2001:2-3), the effective functioning of the interbank market in the South African context requires that it should be flexible and stable as well as liquid, competitive and quickly able to adjust to changes in banking liquidity. The more sensitive interbank rates are to changes in the repo rate, the easier it is for the SARB to influence money market rates by adjusting the repo rate. In addition, it is generally accepted that an efficiently operating interbank market will be characterised by an interbank overnight rate that stays near and slightly below the repo rate (SARB, 2001a:5).

In March 1998, the repo system replaced the previous system of accommodation. Under this old system the Reserve Bank accommodated banks only by way of overnight loans against two categories of financial assets and at two different accommodation rates

(Gidlow, 1998:137). According to Du Plooy (1998:1), there were a number of shortcomings in this system of accommodation. Firstly, since the Reserve Bank always financed the money market shortage fully and automatically at a fixed Bank rate, money market interest rates were insensitive to changes in liquidity. Secondly, in addition to the rigidity of money market rates, the easy access to Reserve Bank funds at a fixed Bank rate also had a depressing effect on the development of interbank trading in surplus funds and discouraged active trading in short-dated government bonds and Treasury bills (Van der Merwe, 1997a:239). Finally, this system of accommodation did not allow the SARB to provide clear signals to the market.

In an attempt to address the above shortcomings, the SARB implemented the repo system of accommodation whereby more active liquidity management through discretionary market operations were applied and repurchase transactions (repos) between the Reserve Bank and the banks became the main instrument to control this liquidity. Repos are contracts involving the simultaneous sale and future repurchase of an asset (Du Plooy, 1998:2; van der Merwe, 1997a:246). The objective of the Reserve Bank in utilising repos as the main instrument of monetary control was to increase flexibility in the determination of money market interest rates.

Although this system served the needs of the banking sector well and the repo rate became a very useful instrument of monetary policy, it was found to have a number of weaknesses. A first problem was that the system had not always been allowed to function as it was originally intended. Secondly, the system was not equipped to be able to address certain issues hampering the effective functioning of the interbank market (SARB, 2001a:3). An example of the latter was the extreme stickiness in the interbank overnight call rates during times of extreme turbulence such as occurred during the emerging market crisis in 1998 (Gidlow, 2001:2; SARB, 2001a:4). In addition, there were certain features of the domestic money market that were identified by the authorities as undermining the efficiency of the refinancing system.

The first concern raised with regard to the functioning of the South African interbank market was that the price discovery process in the interbank market was impaired, that is, it was difficult to establish the precise levels of interbank rates, and interbank dealings did not always take place at the rates that were posted. Secondly, the big four banks dominated the market and had the ability to influence rates. Thirdly, there existed a large differential between the repo rate and the interbank rate, which reduced the level of participation in the daily repo tenders and therefore inhibited the development of interbank market activities. The authorities believed that if the smaller banks could borrow more cheaply by means of repos, they would become more active in the interbank market and this might then contribute to the competitiveness in this market (Gidlow, 2001:4). Finally, the interbank market did not always clear effectively.

There were also several deficiencies identified with the repo system of accommodation. The liquidity shortage, i.e. the money market shortage was small relative to the size of the market and, as a result, the SARB had a reduced influence over interest rates. The big banks were thus seen as “immune” at least to some extent, to the open market transactions conducted by the Reserve Bank (SARB, 2001a:12). In addition this system required that both the repo rate and repo tender are fixed, which was unsuitable for the implementation of monetary policy. It was believed that one of the two should be allowed to float in order for banks to send signals to the Reserve Bank concerning their liquidity needs. Finally, the Reserve Bank's refinancing procedures were criticised for a lack of transparency, especially in terms of its open market transactions used to drain liquidity from the market. It was argued that instead of the SARB conducting foreign exchange swaps on a bilateral basis between itself and one other counterparty, it should hold auctions where all banks could in principle bid for the funds offered by the Reserve Bank (Gidlow, 2001:5).

As a result of the shortcomings of the 1998 accommodation system, the SARB conducted comprehensive research involving consultations with the South African banking sector, the Bank of International Settlements (BIS), the International Monetary Fund (IMF), as well as experts from other central banks, in order to identify modifications to the refinancing system that would address these weaknesses (SARB, 2001b:1). According to the SARB (2001b:2), the following modifications were made to the 1998 accommodation system.

- A one-off adjustment to the spread between the interbank call rate and the repo rate was made by appropriately lowering the Reserve Bank's repo rate. The SARB made it clear that this adjustment was purely administrative and did not imply a change in monetary policy stance.
- In order to enhance the functioning of the interbank market, the SARB would calculate on a daily basis a South African Overnight Index Average (SAONIA), which was intended to serve as a benchmark for money-market interest rates.

- The repo rate was changed from a floating to a fixed rate by the SARB so as to eliminate any ambiguity with regard to the Reserve Bank's monetary policy signals.
- As an incentive for banks to square off in the interbank market, the SARB terminated its previous practise of announcing the forecast liquidity requirement prior to the repo auctions. Instead, the SARB announced the tender amount provided and the amount allotted in the repo tenders shortly after the tender.
- As an additional incentive for the interbank market to clear, the SARB replaced the daily tenders with weekly repo tenders that had a seven-day maturity.
- The SARB conducted, at its discretion, daily final clearing repos, reverse repos or supplementary tenders, which enabled banks to square off their positions.
- The SARB placed a limit on the net daily amount that banks could withdraw from or deposit in their cash-reserve contra accounts.

In order to calculate the minimum reserve balances to be held by banks and the cash reserve accounts in the Reserve Bank, the SARB reduced the amount of vault cash that qualified to 75 per cent of the previous total amount of vault cash held. This limit was later reduced by a further 25 percentage points per year.

The first adjustment, bullet point one, was a change in the operating target rate in order to influence more directly the private bank-to-bank lending rate (interbank rate). This is because as noted in the introduction, the monetary authorities believed that the money market would function most efficiently if changes in the repo rate first affected the interbank rate, which then transmitted these effects to other money market rates, followed by other interest rates in the economy. Thus, as a result of the change, the monetary authority is expected to have altered the interest rate transmission channel, since it was previously believed that changes in the repo rate were often directly followed by changes in the prime overdraft rate and other rates of banks, which then affected money market rates (Gidlow, 2001:3). We turn to the transmission mechanism next.

3. Monetary policy transmission mechanism: an overview

The monetary policy transmission mechanism (MPTM) describes the complex process through which a change in monetary policy stance is transmitted to achieve the goal of monetary policy, such as a stable and low inflation and economic growth. The subject of MPTM has received growing interest among researchers, economists and central banks, with the result that a large body of theoretical and empirical studies have emerged. This includes Mishkin (1995), Taylor (1995), Peersman (2001) and Smal and Jager (2001) and Faure (2005). Faure (2005: chp. 12) also provides a detailed review of the different central bank's views and a discussion of the views on a monetary transmission mechanism in South Africa.

From the literature, four aspects of the transmission process can be identified, namely, the stages, channels, magnitude and speed of the transmission process. Given the complexity of the transmission process, there is no consensus of views on the different stages or on the different channels. Faure (2005: 218) identifies six stages in the transmission process. The stages[1] are:

- Stage 1: transmission of central bank lending rate to the private bank-to-bank interbank market
- Stage 2: transmission of interbank rates to other market interest rates
- Stage 3: transmission of interest rate changes to asset prices, expectations and the exchange rate
- Stage 4: transmission of changes in asset prices, expectations and the exchange rate to aggregate demand
- Stage 5: transmission of changes in aggregate demand to money
- Stage 6: transmission of changes in aggregate demand, money, etc to prices

In most stages of the transmission process, different channels of transmission may be used. Most of the commonly identified channels in the literature, such as the bank lending channel, the balance sheet channel, the cash flow channel and the unanticipated price change channel lie between stages 3 and 6 above. Monetary authorities are keen to know which channel will transmit monetary policy most effectively. For the purpose of this study, we focus on stages 1 and 2 of the transmission process.

A large body of studies on transmission from stages 1 to 2 focus on the magnitude and speed of the transmission process, while giving no attention to the different channels at these stages. See for instance, Aziakpono, *et al.* (2005) for a review of such studies and an empirical analysis of the size and speed of the interest rate pass through process in South Africa. The importance of the size and speed of transmission is succinctly illustrated in Aziakpono *et al.* (2005:6): "If, for instance, the response of market interest rates is too small to be noticed, or delayed or sluggish, the monetary policy may not

[1] For a detailed description of each of the stages see Faure (2005).

achieve the desired goal, irrespective of the size or magnitude of the change in the official interest rate." Thus the speed and size of the response of interest rates are very important for effective monetary policy. This explains why there is an increased interest among policy makers and researchers in knowing why there are rigidities in market interest rates and the extent thereof.

However, besides the speed and size of adjustment of interest rates to changes in the official rates, the transmission paths of the interest rates between stages 1 and 2 are also important. This is because different interest rates may respond differently to a change in the official rates. Besides the central bank lending rate (repo rate), there is an array of interest rates, ranging from the private bank-to-bank lending rate (interbank rate), call money market rate (call money rate), other money market rates (such as treasury bill rates (TBs) and NCD rates), deposit rates, to bank lending rates (such as the prime overdraft rate, prime lending rate and ordinary lending rate), as well long term rates (bond rates). Some of these rates are wholesale rates while others are retail rates. In implementing monetary policies, central banks usually target the short-term wholesale interest rates, such as the interbank rate or the prime overdraft rate. Most central banks find the overnight interbank rate the easiest rate to influence (ABSA 2001:2). In South Africa, prior to 2001, the interbank overnight rate was never the focus of monetary policy implementation. Instead the prime overdraft rate was emphasised (ABSA 2001:3). The belief that monetary policies will become more effective if their implementations target more closely the overnight interbank rate led to the change to the repo system in 2001.

Consider a situation in which the monetary authority adopts a contractionary monetary policy by increasing the repo rate. This action will lead to a rise in the other interest rates in the economy, thus increasing the cost of capital, causing a fall in investment expenditure, thereby leading to a fall in aggregate demand and a fall in aggregate output. Among the different interest rates different transmission paths can be envisaged to bring about the effects of the policy stance. With regard to the repo system, the alternative transmission paths before and after the adjustments are presented below. The first bullet point represents the path that was expected after the change in 2001, while the second bullet point represents what was believed to have been in operation prior to the change. Both paths rely on the use of the repo rate as the main instrument of monetary policy, but the divergence occurs with the operating target rate.

The MPTM schematic paths as expected since 2001 can be represented as follows:

- Repo rate↑ » interbank rate↑ » call money rate↑ » other bank deposit and money market rates↑ » bank lending rates↑.

According to this transmission path, an increase in the repo rate will immediately cause an increase in the interbank rate, which in turn will cause an increase in the call money rate, then other bank deposit and money market rates and finally the bank lending rates. As noted earlier, it was believed that an opposite mechanism was in operation prior to the adjustment to the repo system in 2001 (ABSA 2001:3). This implies that an increase in the repo rate would first have an impact on the interbank rate, which is then transmitted to the other bank lending rates, followed by other deposit and money market rates, then the call money and finally the interbank rate. Thus the above transmission paths can be rewritten as follows:

- Repo rate↑ » prime overdraft rate↑ » other bank lending rates ↑ » other bank deposit and money market rates ↑ » call money rate ↑ » interbank rate↑.

The empirical question that needs answering therefore is whether the expected change in the transmission path occurred or not and whether the change to the repo system 2001 has had a more direct influence with a concomitantly stronger impact on the interbank rate then on the other interest rates. In the next section, we discuss the framework used in addressing these issues.

4. Analytical framework

4.1 Model specification

The primary model used to capture the various relationships between the repo rate, the interbank rate, the prime lending rate and the money market rate is specified thus:

$$r^j{}_t = \alpha_0 + \beta_1 r^i{}_t \qquad (1)$$

where, i and j are the different interest rates while α_0 and β_1 are the intercept and slope parameters respectively; and ε_t is the stochastic error term. A significant with a magnitude close to one of the slope parameter would indicate a strong relationship between the interest rates. In the context of our analysis, it will be recalled that one of the objectives of the change in the policy was to force the influence of a change in the repo rate to have a more direct and stronger influence on the interbank rate, which would in turn be transmitted to the interest rates in the economy. In order to determine whether the change to the repo system in 2001 has had the desired effect, we will examine the empirical relationship between the interest rates for the period before and after the adjustment, that is, March 1998 to September 2001 and September 2001 to November 2004. If the aim of the adjustment has been realised, it is expected that the long run relationship between the pair of interest rates should be stronger (i.e. a higher and more significant slope parameter) after the adjustment than before it. Besides the stronger long run relationship as noted above, the transmission paths should also have changed with the adjustment of the repo system. The change to the transmission paths is determined by examining the pattern of the causal relationships among the interest rates in relation to the expected channel of transmissions before and after the change. The econometric tasks involved in the empirical analysis are discussed next.

4.2 Econometric procedure

The study employs the Granger causality test using the error correction modelling (ECM) framework to empirically analyse the relationships specified in (1). The steps involved in the procedure are outlined below.

Granger causality using the ECM framework

The standard Granger causality test requires that the variables under consideration be stationary (Islam and Ahmed, 1999:103). In practice though, most macroeconomic and financial time series are often non-stationary. If the variables are non-stationary, application of the standard Granger causality test to the series in level will produce spurious causality results. In order to circumvent this problem, some authors have suggested the use of a differenced series in the Granger causality test, but this process disregards useful long-run information on such causal relationships (Islam and Ahmed, 1999:101). The ECM framework takes into account the time series property of the underlying series as well as retaining the long-run information on the causal relationship.

The general starting point of the procedure is the test of the unit root to determine the order of integration of the relevant variables followed by a cointegration test to determine whether a long run relationship exists between the variables. In the absence of non stationary and cointegrated series, the test naturally boils down to the simple standard Granger causality test.

Unit root test:

For the purpose of testing for unit root in the series, the study employs the popular Augmented Dickey-Fuller (ADF) test. This entails the estimation of the following regression:

$$\Delta Y_t = \beta_1 + \partial Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \qquad (2)$$

where ε_t is a pure white noise error term and $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. The null hypothesis is that $\partial = 0$ (has a unit root) and the alternative is that $\partial < 0$ (stationary). In estimating the equation, if the t (= τ) value of the lagged coefficient is greater than the critical τ value, at the various levels of significance, then the null hypotheses that the series has a unit root can be rejected and it can be concluded that the series is stationary. If the series is found to be non-stationary, the next step is to test for cointegration.

Cointegration test:

Two approaches were explored to test for cointegration between the series, namely: the Engle-Granger (EG) test and the Guisan (2001) mixed dynamic model method. Another commonly used approach is based on the maximum likelihood technique (Johansen, 1988, and Johansen and Jesulius, 1992). Since the analysis deals with two variables at a time, we considered the methods chosen adequate[2] .

The Engle-Granger test involves a number of steps. First using series of the same order of integration, the relationships specified in equation (1) above are estimated with the use of the ordinary least squares (OLS) method. Next, for each of the relationships estimated, the residual series is generated and subjected to a unit root test using the ADF test. However, since the estimated error terms (u_t) are based on the estimated cointegrating parameter, the ADF critical values are no longer appropriate (Gujurati, 2003:823). Instead, Engle and Granger (1987:269) have calculated the appropriate values. If the residuals of the regressions are found to be stationary, i.e. I(0), then a linear combination of two non-stationary series exists, thus the estimated regression is not spurious. This means that there is a long-run equilibrium relationship between the variables. This test is complemented by the CRDW. In the CRDW, we use the Durbin-Watson d statistic obtained from the cointegration regression. The hypothesis tested here is that d = 0 instead of the standard d = 2. Under the null hypothesis of non-cointegration, CRDW should be close to zero; hence we seek a value of the CRDW that is high enough to reject the null hypothesis.

[2] If there were more than one explanatory variable in the regressions the maximum likelihood approach would be preferred.

Guisan (2001) proposed a mixed dynamic model method as an alternative approach to the EG just described. Guisan (2001:1) notes that a rejection of the cointegration between variables in the EG in many cases may often be no more than a simple problem of misspecification in the form of the relation. After a number of tests, Guisan (2001:1) found that a mixed dynamic model was superior to both a model in levels and a model in first differences. More specifically, the mixed dynamic model was superior to the other two in that it had the lowest level of acceptance of spurious relations. The model is specified thus:

$$Y_t = \Delta X_t + Y_{t-1} + \varepsilon_t \qquad (4)$$

The above equation states that Y_t is a function of the first difference of X_t as well as its own lag (1 lag). The ensuing test of cointegration corresponds to the EG as described above. The stage is the causality testing.

Causality test

The final stage of the analysis entails the test of causality using the ECM framework. This model involves the first differences of the non-stationary, cointegrated variables, as well as the lagged residual of the long-run equilibrium model (Islam and Ahmed, 1999:101) as in equation (7a).

$$\Delta Y_t = \alpha_0 + \alpha_1 U_{t-1} + \sum_{i=1}^{m} \delta_{1i} \Delta Y_{t-i} + \sum_{j=1}^{n} \delta_{2i} \Delta X_{t-j} + \varepsilon_t \qquad (7a)$$

$$\Delta X_t = \alpha_0 + \alpha_1 U_{t-1} + \sum_{i=1}^{m} \delta_{1i} \Delta Yt_{t-i} + \sum_{j=1}^{n} \delta_{2i} \Delta X_{t-j} + \varepsilon_t \qquad (7b)$$

As noted by Nell (1999:13), a variable X is said to cause Y (i.e. the null hypothesis that X does not Granger cause Y is rejected) if the lagged coefficients of the δ_{2i} in equation (7a) are jointly significant, based on the standard Wald F-test. To examine whether Y Granger causes X the ECM equation is estimated with the first difference of the X variable as the dependent variable (7b). The null hypothesis in this case is that Y does not Granger cause X and it is rejected if the lagged coefficients of the δ_{1i} s in equation (7b) are jointly significant (Nell, 1999:13).

The lagged residual of the long-run equilibrium model U_{t-1} in equations (7a) and (7b) is derived from the cointegrating regression estimated above and it differentiates the ECM from the standard Granger causality regression (Islam and Ahmed, 1999:102). The inclusion of this term ensures that causality must exist in at least one direction and such causality can be detected if the error-correction term U_{t-1} is statistically significant, in which case cointegration exists.

5. Empirical results

For the purposes of the analysis, four interest rates have been selected, viz: the repo rate (RR), the prime interbank rate (PIBR), the prime lending rate (PLR), and a money market rate (MNR). For the money market rate, the 3-month NCD rate was used as opposed to the 3-month bank acceptance (BA) rate or 3-month Treasury bill (TB) rate. The analysis covered the period March 1998 – November 2004, which is further sub-divided into two periods: March 1998 - September 2001 and September 2001 to November 2004. This data has been compiled by QUOIN Institute (Pty) Limited from SARB sources and other money market participants.

5.1 Unit root results

The results of the unit root tests for the periods March 1998 to November 2004; March 1998 to September 2001; and September 2001 to November 2004 are presented in Table 1.

TABLE 1: ADF UNIT ROOT TESTS

	Level	Lag length	1st difference	Lag length
March 1998 – November 2004				
Repo (RR)	-2.857418[a]	3	-4.550335[a]	2
Interbank (PIBR)	-0.950448	1	-5.676221[a]	0
Prime (PLR)	-0.911091	2	-4.016145[a]	1
NCD (MNR)	-0.918388	1	-5.426442[a]	0
March 1998 – September 2001				
Repo (RR)	-1.032236	0	-3.270421[a]	2
Interbank (PIBR)	-0.873517	0	-2.983697[a]	3
Prime (PLR)	-0.985383	0	-4.618096[a]	3
NCD (MNR)	-0.761187	0	-4.046121[a]	0
September 2001 – November 2004				
Repo (RR)	-0.623842	0	-2.370273[b]	1
Interbank (PIBR)	-0.446406	0	-2.702198[a]	1
Prime (PLR)	-0.620004	0	-2.370273[b]	1
NCD (MNR)	-0.497156	1	-2.827004[a]	0

Note: [a] Indicates significance at the 99 percent confidence level; [b] Indicates significance at the 95 percent confidence level; and [c] Indicates significance at the 90 percent confidence level.

The optimum lag lengths for each of the variables have been chosen using the Eviews 5 automatic lag selection option and are based on the Schwarz information criterion (SIC). Also the unit root test was carried out with an intercept. The results show that none of the variables are level stationary, i.e. I(0), however, all the variables are first difference stationary, i.e. they are I(1). The exception here is the RR series for the period March 1998 to November 2004, which is level stationary. This result does not allow for the comparison of the RR series with the other series, as they are not integrated in the same order. Since the main focus of this research is to test the relationship between the repo rate and the other rates in the banking system, this period, i.e. March 1998 to November 2004, will not be further analysed. However, all the variables for the two sub-periods under review are first difference stationary and as such a comparison between these variables is feasible. Having established that the data sets of the four variables are integrated in the same order, we now proceed to test for cointegration.

5.2 Cointegration analysis and long-run relationships

The relationships specified in 5.2 have been estimated with the help of OLS for the periods March 1998 to September 2001; and September 2001 to November 2004. In order to test for cointegration, i.e. the feasibility of the regressions, the residuals of each of the relationships have been generated and subjected to unit root tests.

According to Gujurati (2003:823), when testing the residuals of the regressions for unit roots, the normal ADF critical significance values are no longer appropriate values. Instead Engle and Granger (1987:269) have calculated the appropriate values. According to MacKinnon (1991:14), the formula for calculating the exact critical values is given as: $\beta_\infty + \beta_1 / T + \beta_2 T^2$, where for two variables without trend: $\beta_\infty =$-3.9001; -3.3377; -3.0462; $\beta_1 =$-10.534; -5.967; -4.069; $\beta_2 =$-30.03; -8.98; -5.73 for the1%; 5%; and 10% levels of significance respectively; and $T =$ number of observations in data set.

The cointegration results based on the EG[3] were quite weak when compare with the other methods. The EG results suggest very weak evidence of cointegration among the interest rates for the sub period September 2001 to November 2004 , even though the other methods indicate otherwise. For the sub-period March 1998 to September 2001, the EG results show that the prime lending rate and interbank rate as well as the money market and repo rates led to a rejection of the null of no cointegration at the 1% level; while, for the prime lending rate and repo rate, the hypothesis was rejected at the 5% level; and, for the interbank rate and the repo rate the hypothesis was rejected at the 10% level. Whereas, for the interbank and money market rates as well as the prime lending

[3] Given the weak results obtained from the EG approach, we did not report them here to save space.

and money market rate the null of no cointegration could not be rejected at standard significant levels.

However, based on the theory of the transmission mechanism of monetary policy, it would be expected that all these rates should have a meaningful relationship. The rather weak long run relationship among the interest rates may be due to the weaknesses of the EG approach as noted earlier. Guisan (2001:1) has shown that the mixed dynamic model leads to the highest probability of accepting clear cointegrating relations with the lowest risk of accepting non-cointegrating relations.

The results based on the mixed dynamic model show that all the pair interest rates are cointegrated for both the sub-periods. The results are reported in Tables 2 and 3.

TABLE 2: COINTEGRATION TESTS AND LONG RUN RELATIONSHIP RESULTS (MARCH 1998- SEPTEMBER 2001)

Y_t	Coefficient					R^2	F stat	CRDW	ADF
	Constant	**PIBR**	**MNR**	**PLR**	**RR**				
PIBR	-3.60024 (-14.093)[a]				1.11999 (64.205)[a]	0.9901	4122.3	0.9437	-3.2185[a] (lag 0)
PIBR	-5.71689 (-7.5917)[a]			1.05110 (24.489)[a]		0.9360	599.73	0.9671	-7.9173[a] (lag 3)
PIBR	-1.56447 (-4.6197)[a]		1.07935 (42.598)[a]			0.9779	1814.6	1.4426	-1.9817[b] (lag 5)
PLR	2.78489 (5.4172)[a]				1.01132 (28.809)[a]	0.9529	829.96	0.9012	-3.7265[a] (lag 1)
PLR	4.58778 (9.4540)[a]		0.97737 (26.918) [a]			0.9464	724.62	0.9754	-2.9361[a] (lag 1)
PLR	6.18952 (13.154)[a]	0.89050 (24.489)[a]				0.9360	599.73	0.9621	-4.2171[a] (lag 1)
MNR	-1.67029 (-5.4523)[a]				1.02248 (48.878)[a]	0.9831	2389.0	1.4762	-4.8424[a] (lag 0)
MNR	-3.75333 (-5.9468)[a]			0.96836 (26.918)[a]		0.9464	724.62	0.9988	-3.0176[a] (lag 1)
MNR	1.70183 (6.1839)[a]	0.90601 (42.598)[a]				0.9779	1814.6	1.4611	-3.0024[a] (lag 5)
RR	3.32292 (18.650)[a]	0.88406 (64.205)[a]				0.9901	4122.3	0.9376	-3.1654[a] (lag 0)
RR	-1.95456 (-3.4061)[a]			0.94225 (28.809)[a]		0.9529	829.96	0.9002	-3.6493[a] (lag 1)
RR	1.84596 (7.0210)[a]		0.96151 (48.878)[a]			0.9831	2389.0	1.4517	-4.7536[a] (lag 0)

Note: [a] Indicates significance at the 99 percent confidence level; [b] Indicates significance at the 95 percent confidence level; and [c] Indicates significance at the 90 percent confidence level. Following Guisan (2004) we used the ADF critical values for the cointegration test in the level model.

TABLE 3: COINTEGRATION TESTS AND LONG RUN RELATIONSHIP RESULTS (SEPTEMBER 2001-NOV 2004)

Y_t	Coefficient					R^2	F stat	CRD W	ADF
	Constant	**PIBR**	**MNR**	**PLR**	**RR**				
PIBR	0.07711 (0.31268)				0.90757 (39.434)^a	0.9767	1555.0	0.4676	-2.9067^a (lag 0)
PIBR	-3.09938 (-9.51347)^a			0.90757^a (39.434)		0.9767	1555.0	0.4676	-2.9067^a (lag 0)
PIBR	0.32499 (0.97128)		0.90325 (28.325)^a			0.9559	802.351	0.6027	-2.2517^b (lag 1)
PLR	3.66043 (13.6786)^a	1.07623 (39.434)^a				0.9767	1555.0	0.4592	-2.8407^a (lag 0)
PLR	3.50000 (9.11E+15)^a				1.00000^a (2.79E+16)	1.0000	9.47E-30	0.0833	0.0000 (lag 0)
PLR	3.74495 (17.1002)^a		0.99799 (47.817)^a			0.9840	2286.4	1.2642	-2.3138^b (lag 1)
MNR	-0.07831 (-0.3544)				0.98605 (47.817)^a	0.9840	2286.4	1.2552	-2.3672^b (lag 1)
MNR	0.10789 (0.29452)	1.05830 (28.325)^a				0.9559	802.35	0.5854	-2.1967^b (lag 1)
MNR	-3.52951 (-12.091)^a			0.98605^a (47.817)		0.9840	2286.4	1.2552	2.3672^b (lag 1)
RR	0.16043 (0.59953)	1.07623 (39.434)^a				0.9767	1555.0	0.4592	-2.8407^a (lag 0)
RR	-3.50000 (-2.18E+15)^a			1.0000^a (8.82E+15)		1.0000	9.47E-29	0.0666	-0.8056 (lag 0)
RR	0.24495 (1.1185)		0.99799 (47.817)^a			0.9840	2286.4	1.2642	-2.3138^b (lag 1)

Note: ^{a} Indicates significance at the 99 percent confidence level; ^{b} Indicates significance at the 95 percent confidence level; and ^{c} Indicates significance at the 90 percent confidence level. Following Guisan (2004) we used the ADF critical values for the cointegration test in the level model.

A close examination of the results reveals that in general the response of interest rates is very high in both periods across all the pairs of interest rates. The differences between the two periods are very marginal. There was virtually a one-on-one response in all the cases and the parameters were highly significant (at 1% level). With specific reference to the response of the interbank rate to the repo rates, the results show that some shifts in the two periods have occurred though not significant. For instance, prior to the adjustment of the repo system, the response of the interbank rate to a change in the repo rate was approximately 1.12 (i.e. 112 percent - some overshooting occurred then), but following the change to the repo system, the response dropped to 0.91 (i.e. 91 percent).

We also consider the possibility of the repo rate responding to a change in the interbank rate. For the period before the adjustment, the repo rate responded by about 88 percent; whereas, after the adjustment, the response of the repo rate increased to 108 percent (an overshooting occurred). This trend is rather surprising since it shows that the repo rate has tended to exert less influence on the interbank rate since the adjustment than before it. Paradoxically, the interbank rate has exerted a stronger influence on the repo rate than the repo rate has done on the interbank rate since the change; while the reverse was the case prior to the change.

It is also noticed that the prime lending rate and the repo rate during the second period changed by exact the same amount at the same time and thus are interchangeable. On the whole, given the high level of interest rates pass-through in South Africa, it would appear that targeting any of the wholesale interest rates would generate a similar magnitude of interest rate responses. We turn to the causality tests results next.

5.3. ECM causality results

Table 5 presents the causality results based on the ECM framework between the variables under study for the period before the change from a floating to a fixed repo system. The analysis in this section focuses on the pattern of causality among the variables in relation to the expected pattern before and after the adjustment to the repo system.

Based on the order of significance of the tests, three patterns in the direction of causality between these variables arise. These are as follows:

(1) RR → PIBR → MNR → PLR

(2) RR → MNR → PLR → PIBR

(3) RR → MNR → PIBR → PLR

Out of these three patterns, it is the first one (1) that has the strongest causality and as such it is the most likely order in which changes in monetary policy were transmitted through the banking system during this period. What is remarkable about option (1) is that the direction of causality is the channel that the monetary authorities hoped to achieve by changing this repo system in September 2001 and not the direction that was thought to be in operation at this time. In other words, the desired transmission channel was already in use before the changes to the repo system.

Table 5: ECM causality results for 1998-2001			
X does not Granger cause Y	**F statistic/Wald test**	**Probability**	**Accept/reject Null**
RR does not Granger cause PIBR	5.525977	0.025503	Reject (at 5%)
PIBR does not Granger cause RR	0.028794	0.866880	Accept
PLR does not Granger cause PIBR	3.506711	0.075111	Reject (at 10%)
PIBR does not Granger cause PLR	3.691744	0.066636	Reject (at 10%)
MNR does not Granger cause PIBR	10.35456	0.003093	Reject (at 1%)
PIBR does not Granger cause MNR	23.51359	0.000024	Reject (at 1%)
RR does not Granger cause MNR	35.74171	0.000001	Reject (at 1%)
MNR does not Granger cause RR	0.662990	0.428244	Accept
MNR does not Granger cause PLR	15.19237	0.000505	Reject (at 1%)
PLR does not Granger cause MNR	0.911152	0.352453	Accept
RR does not Granger cause PLR	0.807787	0.380641	Accept
PLR does not Granger cause RR	0.231645	0.634184	Accept

TABLE 6: ECM CAUSALITY RESULTS FOR 2001-2004			
X does not Granger cause Y	**F statistic/Wald test**	**Probability**	**Accept/reject Null**
RR does not Granger cause PIBR	2.414013	0.130089	Accept
PIBR does not Granger cause RR	14.22757	0.000740	Reject (at 1%)
PLR does not Granger cause PIBR	2.414013	0.130089	Accept
PIBR does not Granger cause PLR	14.22757	0.000740	Reject (at 1%)
MNR does not Granger cause PIBR	0.049695	0.825157	Accept
PIBR does not Granger cause MNR	16.30842	0.000314	Reject (at 1%)
RR does not Granger cause MNR	37.72508	0.000001	Reject (at 1%)
MNR does not Granger cause RR	25.11505	0.000019	Reject (at 1%)
MNR does not Granger cause PLR	25.11505	0.000019	Reject (at 1%)
PLR does not Granger cause MNR	37.72508	0.000001	Reject (at 1%)
RR does not Granger cause PLR	Cannot be estimated (near singular matrix)		
PLR does not Granger cause RR	Cannot be estimated (near singular matrix)		

Table 6 presents the causality results for the period after the changes to the repo system in September 2001. As mentioned above, one of the objectives of the SARB when making the changes to the repo system was to have the direction of causality run from the repo rate to the interbank rate, then to money market rates and finally impact on other rates in the economy. There are four possible patterns relating to the direction of causality between the variables under study in this period. These are as follows:

(1) PIBR $\rightarrow$ RR $\rightarrow$ MNR $\rightarrow$ PLR

(2) PIBR $\rightarrow$ PLR $\rightarrow$ MNR $\rightarrow$ RR

(3) PIBR $\rightarrow$ MNR $\rightarrow$ PLR

(4) PIBR $\rightarrow$ MNR $\rightarrow$ RR

All the above options have rejected the null hypothesis of no-causality at the 1% level of significance and as such all have an equal chance of being the true direction of causality during this period (September 2001 to November 2004). It should be noted however, that during this period changes in the repo rate have resulted in an equal and immediate change in the prime-lending rate. This essentially means that there are in fact only two apparent options for the direction of causality during this period as changes in the repo rate are exactly equal to changes in the prime-lending rate.

An interesting observation from the above results is that the prime interbank rate is not caused by any other rate and as such is the starting point for the transmission mechanism of monetary policy. This result may seems surprising, as it often thought that the official rate (the repo rate) should lead all the interest rates and thus be the starting point of the transmission mechanism. However, based on the option (1), the transmission mechanism of monetary policy starts with the interbank market, which then influences the repo rate, which in turn affects the money market rates and finally impacts on the prime lending rate. Option (2) has a similar direction (since changes in the repo rate and prime-lending rate are equal). Options (3) and (4) represent the transmission mechanism as running from the interbank rate to money market rates and then to the repo and prime lending rates.

A possible explanation for the transmission mechanism having its starting point in the interbank market may be due to the fact that the repo rate is administratively determined while the interbank rate is market determined. In an attempt to keep the repo rate close to the interbank rate, since September 2001 the MPC has adopted a one-off adjustment to the repo rate after considering the macroeconomic fundamentals and the liquidity conditions in the money market. Usually, the behaviour of the interbank rate depends on the level of liquidity in the market. In the event of liquidity shortage, the forces of market will drive up the interbank rate which in turn will widen the gap between the two rates. Consequently, the MPC will adjust the repo rate to reduce the gap. Thus as long as the repo rate depends on the liquidity situation in the market it sounds logical therefore, that, to some extent, the behaviour of the interbank rate would lead the repo rate.

6. Conclusion

The study set out to examine the influence of the repo rate on the interbank rate, as well as to analyse whether the transmission channels of interest rates have changed since the adjustment to the repo system. One objective of the monetary authorities when changing the repo system in September 2001 was to strengthen the relationship between the repo rate and the interbank rate. The results suggest that the influence of the repo rate on the interbank rate tended to be stronger before the adjustments to the system were made. In addition, the interbank rate and the repo rate were found to "reverse" roles in the period after the adjustments to the system. This was seen both in terms of the direction of causality as well as in the adjustments of other rates in response to a 100 basis point increase in these rates.

It was found that the route for the transmission of monetary policy that the authorities wished to implement by changing the repo system was already in place prior to the change. More specifically, in the period before the change, causality ran from the repo rate to the interbank rate, which then affected the prime lending rate via the money market rate. This was the transmission mechanism believed by the monetary authorities to be the best for an efficiently functioning money market. In the period after the change however, the direction of causality changed to run from the interbank rate to the repo rate, which then influenced money market rates and eventually the prime lending rate. This caused a reversal of roles between the repo rate and the interbank rate in the period after the change to the repo system. This result is surprising as the repo rate is administratively determined and so it would have been expected that the starting point for monetary policy should be changes to the repo rate.

In sum, the above analysis reveals that the SARB has not achieved its objective of having the repo rate impact more directly on the interbank rate. In fact, the direction of causality before the change was the direction the authorities were hoping to achieve by making the changes to the repo system, whereas, after the change, the transmission mechanism altered changed to one that was not desired by the authorities. Thus, in terms of this particular objective, the SARB should not have changed the system in September 2001. However, the fact that the adjustment to the repo system has helped to stabilize the volatility of interest rates experienced in the initial periods makes it commendable.

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