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Hasan Cömert

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Gordon Hall
418 North Pleasant Street
Amherst, MA 01002

Phone: 413.545.6355
Fax: 413.577.0261
peri@econs.umass.edu
www.peri.umass.edu

UMASS

# Decoupling between the Federal Funds Rate and Long-term Interest Rates: Decreasing Effectiveness of Monetary Policy in the US[+]

**Hasan Cömert**[*]

## Abstract

This paper investigates the relationship between overnight interest rates and the long-term rates in the US from 1983q1 to 2007q3. It presents evidence supporting the argument that there was a gradual decoupling between the Fed interest rate and long-term interest rates even before the recent crisis. In other words, the Fed was gradually losing its control over long-term interest rates. As opposed to many economists' claims, the period after 2001 was a continuation of a process which has surfaced since the end of the 1980s. Both descriptive statistics and different econometric techniques robustly support the argument that the decoupling began way earlier than 2001. Furthermore, the purchase of the US assets by foreigners might have played some role in this process although the findings related to this are not very robust.

**JEL Classification**: E52, E58, E43, G12
**Key Words**: Central Banking, Federal Funds Rate, US Monetary Policy, Short-Term and Long Term Interest Rates and Decoupling.

## A Introduction

Recently, central bankers have been forced to reconsider their theories and practices in response to an unprecedented financial crisis, which began in the US in mid-2007 and has quickly spread to the entire globe. This may be the beginning of the end of a period which commenced full fledge circa 1980.

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[+] This paper is based on one of the four main chapters of my dissertation completed at the Department of Economics at UMass-Amherst (February 2011). I am grateful to my dissertation committee, Jerry Epstein (chair), Arjun Jayadev, Depankar Basu, James Crotty and James Heintz for their helpful comments and guidance. All remaining errors are mine. A slightly different version of this paper will appear as a chapter in H. Comert, *Central Banks and Financial Markets: The Declining Power of US Monetary Policy*, (Edgar Elgar, forthcoming).

[*] Department of Economics, Middle East Technical University, Ankara, Turkey, e:mail: hcomert@metu.edu.tr

Central banking practices before the crisis were mainly based on moving overnight interest rates. This was believed to be enough to stabilize financial markets and reach inflation targets even in a world in which the financial system changed rapidly. According to many, “all that matters is that the Fed be able to control overnight interest rates, this gives it the leverage that it need in order to pursue its stabilization objectives [including price stability]” (Woodford 2002:88). Although central banks aggressively used their interest rate instrument before and during the crisis, their policies did not seem to produce the desired results.

This paper investigates the relationship between overnight interest rates and the long-term rates in the US from 1983q1 to 2007q3. It presents evidence supporting the argument that there was a gradual decoupling between the Fed interest rate and long-term interest rates even before the recent crisis. In other words, the Fed was gradually losing its control over long-term interest rates. As opposed to many economists’ claims, the period after 2001 was a continuation of a process which has surfaced since the end of the 1980s. Both descriptive statistics and different econometric techniques robustly support the argument that the decoupling began way earlier than 2001. Furthermore, the purchase of the US assets by foreigners might have played some role in this process although the findings related to this are not very robust. Two main implications of the paper are that i) using overnight interest rates may not be sufficient to direct developments in an economy (especially in a situation in which other channels of the transmission mechanism deteriorates too), ii) models based on the idea that central banks may exert great influence on economies by affecting long-term interest rates should be reconsidered.

Although there are several studies investigating the relationship between long- and short-rates, this paper is different from others in some distinct ways. First, instead of focusing on only the 10-year Treasury bond rate, this paper investigates the relationship between all important long-term interest rates and the Fed rate because different long-term interest rates may have different dynamics. Second, it presents new evidence on interest rate behavior with important implications for the conduct of monetary policy. Many papers have investigated theoretically the relationship between the Federal Funds rate and long-rates. However, these studies have failed to analyze how the relationship between interest rates has evolved over time. In contrast, this paper investigates how the relationship between the Fed rate and long-rates has evolved since 1983q1 and claims that the relationship between the Fed and other rates has gradually weakened. In this sense, it claims that the last period is the continuation of a process which has been underway since the end of the 1980s (or the beginning of the 1990s).

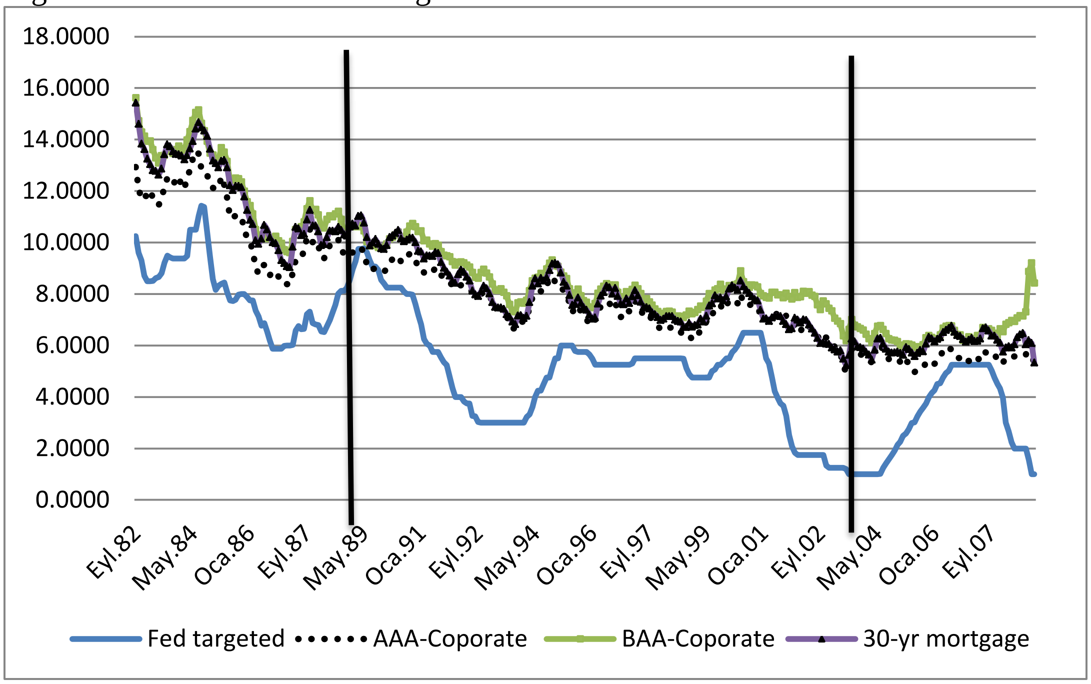
These findings raise concerns about the validity of policies and models based on the presumption of a strong and stable relationship between central bank-controlled interest rates and the rates relevant to economic activity. New models and analysis are needed.

The outline of the paper is as follows. In Part B, with the help of descriptive statistics and a simple correlation framework controlling only the influence of the expected inflation, some general observations concerning the responsiveness of long-term interest rates to the Fed rate are discussed. Part C uses more sophisticated econometric techniques to check the robustness of the results found in Part B. This part also investigates the role of capital flows in determining long-term interest rates. Furthermore, it presents the findings of recursive estimates. The last part concludes.

## B. General Observations about the Fed Rate and Long-Term Rates

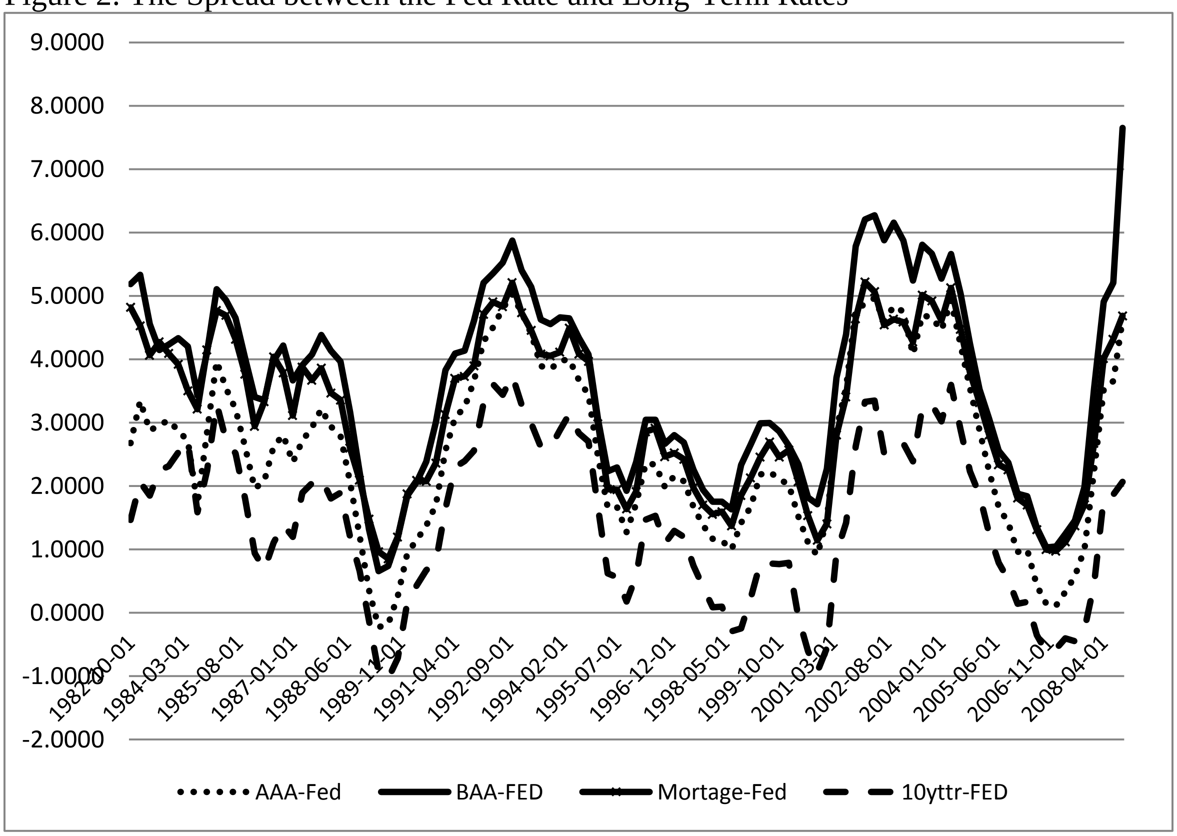
Three important tendencies concerning the relationship between overnight interest rates and long-term interest rates can be distinguished after the 1980s. These are: (1) as many have observed there has been a declining trend in both long-term interest rates and the Fed rate (see Figure 1); (2) the spread between the Fed and long-term interest rates shows a cyclical pattern (see Figure 2); and (3) the responsiveness of long-term interest rates to the Fed rate seems to have gradually decreased throughout the whole period (see Figure 1 and 2).A general decrease in long-term interest rates and the cyclical nature of the spread between long and short-term interest rates have been discussed widely. Especially, the term spread between short-term interest rates and long-term interest rates has been the subject of several studies within the yield curve literature (Campell and Shiller 1991, Campell 1995, Estrella and Mishkin 1996, Estrella 2005 and Wright 2006)**.** However, the last observation that decreasing responsiveness of the long-term rates to the Fed rate, has not been studied or has drawn little attention. As will be discussed below, most of the relevant literature has focused on the development in the relationship between the Fed and long-term interest rates after 2001. Hence, this paper will focus on the responsiveness of the long-term interest rates to the Fed rate.

Figure 1: The Fed Rate and Long-Term Rates




Source: The St Louis' Fed

Figure 2: The Spread between the Fed Rate and Long-Term Rates




Source: The St Louis' Fed

**B.I The Responsiveness of Long-rates to the Fed Rate**

The responsiveness of long-term interest rates to the Fed rate seems to decrease gradually after the end of the 1980s. In the 1980s, the relationship between the Fed rate and other interest rates appears to be strong. Then during the 1990s this relationship seems to loosen. Finally, in the last period, the deterioration of the relationship seems to continue. In the spirit of Friedman (2000), I call this process decoupling between the Fed rate and long-rates

Some other studies also observed that the influence of the Fed on long-term interest rates had decreased. However, almost all of them focused on the period after 2001. According to Greenspan (2005:7-9).

> "Long-term interest rates have trended lower in recent months even as the Federal Reserve has raised the level of the target Federal Funds rate by 150 basis points. This experience contrasts with most experience, which suggests that, other things being equal, increasing short-term interest rates are normally accompanied by a rise in longer-term yields […] "For the moment, the broadly unanticipated behavior of world bond markets remains a conundrum. Bond price movements may be a short term aberration, but it will be some time before we are able to better judge the forces underlying recent experience".

Bernanke (2006) also seemed to be surprised at seeing that long-term bond rates did not move with the Fed rate. He points out "[o]ver the past seven quarters or so, tightening monetary policy has been accompanied by long-term yields that have moved only a little on net."[1] And he asks "why have long-term interest rates not risen more, as they have done over previous policy tightening cycles?" Similarly, Rudebusch, Swanson and Wu (2006:2) accept that "as a broad empirical regularity long-term interest rates tend to move month-by month in the same direction as short-term rates although by a lesser amount".

[1] Bernanke (2006) does not give any clear cut explanation for this phenomenon.

However, they consider that the recent developments (from June 2004 to December 2005) in the relationship between the Fed rate and long-term rates seem to be unusual. Hence, they explicitly "investigate the seemingly odd behavior of long-term interest rates over this recent episode." Using a micro-finance model, Rudebush, Swanson and Wu (2006) claim that the situation during 2004 and 2005 is a conundrum that cannot be explained by their models. Similarly, Ducoudre (2006) also focuses on this period. Following expectations theory, he uses a simulation technique to explain long-run interest rates. According to him, "once we account for agents' short rate and inflation expectations, simulations show that the long-rate would be 70 basis points lower than its forecasted level." These studies more or less share the idea that "until the end of 2001, this trend [movements in long rates] was in step with fundamentals, especially the stable inflation outlook and low nominal short-term rates. More recently, long-term yields have behaved puzzlingly with respect to their traditional determinants" [Idier, Jardet and Loubens (2007:5)].

Although, all these studies have focused on an important period, during which the phenomena of the decoupling was very apparent as I stated before, my claim is different: The last period is a continuation of a process that began in the 1990s. To the best of my knowledge, the only paper which has an argument closer to one advanced here is Thornton's (2010) paper. He (2010:1) states that "there was a statistically significant change in the relationship between Treasury yields and the fund rate that occurred in the late 1980s and that there was no statistically significant change in the relationship before or after that date". However, this paper is distinct from his paper several ways. First, I investigate the relationships between the Fed rate and all relevant long-term interest rates instead of focusing on Treasury bond rates. Second, I focus on the evolution of the relationship and report that there has been a gradual decupling between the Fed and long-term rates. Third, this study utilizes a reduced structural equation instead of using a simple equation having only the Fed rate as independent variable. The variables in the equation used in this study represent monetary policy stance and macroeconomic conditions in which interest rates are determined. Fourth, this study also uses several different regression techniques to check the robustness of the results.

### B.I.a Three Different Sub-Periods

I will check the relationship between the Fed Funds rate and long-term interest rates in three different sub-periods in addition to analyzing the relationship for the whole period. Furthermore, I will also utilize recursive estimates of the coefficients to see the evolution of the relationship since the 1983q1. The sub-periods are determined by using the date of recessions announced by National Bureau of Economics (NBER). Most economic studies use the date of recessions for the purpose of macroeconomic periodization. According to the NBER, after 1982, the first recession in the US began in July 1990 (third quarter) and ended in March 1991 (first quarter). The second recession started in March 2001 (first quarter) and ended in November 2001 (fourth quarter) (NBER web page http://www.nber.org/cycles).[2] In order to be able to have comparable periods, I purged the recession periods from our investigation. In this vein, the periods used in this study are as follows: 1) 1983q1-1990q2; 2) 1991q2-2000q4; 3)2001q1-2007q3. This periodization is in line with the story implied by Figure 1. This periodization is also supported by a battery of econometric tests. First, heteroscedasticity

[2] According to NBER a new recession started in December 2007 (fourth quarter).

tests show that error-terms are homoskedastic in all three distinct periods, whereas the homeskedasticity assumption is rejected for the whole period. Second, F tests show that these three periods are different from each other, Third, according to structural break tests, the beginning of three distinct periods can be accepted as structural break points.

**B.I.b Simple Correlation and Ordinary Least Squares (OLS) Results**

The argument that there has been a gradual decoupling between the interest rates and the Fed rate is supported by simple correlation statistics within an OLS framework. Since the effectiveness of the central bank interest rate is mainly about real interest rates, controlling inflation expectation is necessary. [3] In this vein, the correlation results are obtained after controlling for the influence of the expected inflation. This approach does not give a direct answer to the question: how much has the responsiveness of the long rates to the Fed declined when we control for the influence of some other relevant variables? It only allows me to see if, without keeping other factors constant, correlations between the Fed rate and other rates have changed in these three periods. Nevertheless, from a central banking policy perspective, sometimes simple correlations and OLS with minimum regressors can be very indicative because the results may reflect the link between the policy rate and long-rate in the presence of the noisy effect of other factors. Since the central banking policy objective is to be able to direct long-term interest rates even in the presence of distorted factors, investigating simple correlations and OLS with the minimum number of variable can be an important exercise.

Overtime, simple correlation statistics clearly show there is a considerable decrease in the responses of the long-term interest rates to the Fed interest rate. When we

[3] High nominal interest rates can go hand in hand either with no change or decrease in real interest rates.

look at the correlation between levels in three different periods, it is apparent that the relationship between the Fed rate and long rates has deteriorated considerably (Table 1). In the 1980s the relationship between the Fed and all long-term rates seemed to be very strong. Then in the second period there appears to emerge a huge deterioration in the responsivenesss of all long-term rates to the Fed rate.[4]

Table 1: The Impact of the Fed Targeted Rate on Different Long-Term Rates

| Dependent Variable | Method | Whole | Period1 | Period2 | Period3 |
|---|---|---|---|---|---|
| **AAA** | OLS-Level | 0.252*** | 0.439** | 0.229*** | -0.095* |
| | OLS-Diff | 0.289*** | 0.407*** | 0.316** | -0.003 |
| **BAA** | OLS-Level | 0.234*** | 0.367 | 0.229*** | -0.136** |
| | OLS-Diff | 0.295*** | 0.465*** | 0.296* | -0.055 |
| **10 YR** | OLS-Level | 0.358*** | 0.689*** | 0.326*** | 0.128*** |
| | OLS-Diff | 0.415*** | 0.605*** | 0.400* | 0.026 |
| **MRTG** | OLS-Level | 0.363*** | 0.477** | 0.324*** | 0.091** |
| | OLS-Diff | 0.417*** | 0.592*** | 0.433** | 0.063 |
| note: *** p<0.01, ** p<0.05, * p<0.1 | | | | | |
| Newey-West Procure is used to take care of possible auto-correlation and heteroskedasticity problems. This procedure does not affect the value of coefficients. It only affects the variances | | | | | |

[4] One could argue that market participants pay attention to the expected path of interest rates more than current level of Fed interest rate. According to this view, it would be better to investigate the relationship between the expected path of the Fed rate and long-term interest rates. This seems to be a reasonable argument. However, quarterly data and monthly data already partly reflect some expectations because they are monthly or quarterly average of daily targeted rates. So, they represent some interest rate smoothing which is important for the formulation of expectations about the future path of the Fed target rate. In fact, many studies use the moving average of the Fed rate to represent the expected path of it which is another way of averaging (i.e., smoothing data). However, for the sake of robustness, I also checked the correlation between the 6 quarter moving average of the Fed rate and other long-term interest rates. The basic results did not change. On the contrary, the shift in the relationship between the Fed rates and long rates (apart from treasury rate) is much more dramatic if we consider expected Fed rate measured by moving average of the Fed rate. All results are in line with the findings in the preceding part.

## C. Econometrics of Long-Term Interest Rates

In the preceding section, with the help of descriptive statistics I showed that there was a gradual decoupling between the Fed rate and the long-term interest rates. This finding indicates that when we look at the general picture there has been a decoupling between the Fed rate and long-term interest rates for a long time. In this sense, as opposed to the claims of many economists, the decoupling is not a recent phenomenon. It first appeared at the end of the 1980s (or similarly the beginning of the 1990s). Although this finding is very important from a policy framework, it is necessary to assess the impact of the Fed on long rates with additional techniques. Therefore, in this section, the findings of the previous sections will be further investigated by using more sophisticated econometric techniques, and some important econometric problems will be discussed.

In part C.I the regression specification which will be used in this study will be discussed. Part C.II and C.III will elaborate on the data, econometric issues and regression results respectively.

### C.I The Regression Specification

I initially consider the following regression framework.

$$RL_{t,j} = \alpha_{0,j} + \alpha_{1,j}Fed_t + \alpha_{2,j}\pi_t^e + \sum_{i=3}^{n} \alpha_{i,j} Z_t \qquad (1)$$

This equation can be seen as a reduced structural equation. A similar regression equation can be obtained by using a simple version of IS/ LM model too (Warnock and Wornock 2009). The independent variables in this equation are monetary policy and main macroeconomic variables in an economy. In this vein, these variables represent monetary policy stance and macroeconomic conditions in which interest rates are determined.

$RL_{t,j}$ represents long-term interest rates (10-year Treasury, AAA, BAA bonds and Mortgage rates); $Fed_t$ is the Federal Fund target rate, $\pi_t^e$ is 10 year ahead expected inflation at time t. It is expected that a higher Fed rate may lead to higher long-term interest rates. So, the expected value of the coefficient of this variable is positive. Since investors are mainly interested in real interest rates they demand higher nominal interest rates when expected inflation increases. So, the expected sign of $\alpha_2$ is also positive.

$Z_t$ is a vector of all other variables which will be included in the regression. I will consider $Z_t$ (see equation 2) as a function of three different variables which are emphasized in the literature. Many other variables can be added to the equation. However, this can intensify potential multicollinearity and other econometric problems. Furthermore, being as parsimonious as possible is a necessity when one does not have very large data set because adding too many variables in regression equations can easily exhaust the degrees of freedom

$$Z_t = ( \; RP_t \; Growth_{t,} \, CF_t, ) \qquad (2)$$

So, the main regression which will be used here can be written explicitly as follows:

$$RL_{t,j} = \alpha_{0,j} + \alpha_{1,j} Fed_t + \alpha_{2,j} \pi_t^e + \alpha_{3,j} RP_t + \alpha_{4,j} \, Expgr_t + \alpha_{5,j} \, CF_t \qquad (3)$$

$RP_t$ is a risk premium. In general US long-term interest rates are considered less risky. Since some long-term assets are not kept to maturity; the volatility of the interest rates may be a concern to investors. High volatility in interest rates can lead to lower future asset values. I measure risk premium by the volatility of the relevant interest rates. Investors may demand higher interest rates under risky circumstances. So, the expected sign of $\alpha_3$ is positive. The expected growth can be considered as a proxy for demand pressure (or expected productivity). In the literature, it is generally accepted that the impact of this variable on long-term interest rates is negative.

$CF_t$ is the capital flows variable. The Mundel-Fleming model and other open macro-economic models imply that the influence of capital flows may be negligible in the framework of a large country. Hence, the earlier studies on the US interest rates did not include this variable in their regression analysis. However, many economists started emphasizing the influence of the capital flows especially on the US treasury rates after 2001 (see especially Warnock and Warnock 2009). In this spirit, I added a variable to my regression equation to control for the influence of capital flows. An increase in capital flows may put downward pressure on long-term interest rates. So, the expected sign of $\alpha_5$ is positive.

I estimated the regression equation (3) for four representative long-term interest rates (10-year Treasury, AAA, BAA bonds and Mortgage rates). This allows me to discuss the general picture concerning the relationship between the Fed Funds rate and all important long-term interest rates. Focusing on several important interest rates, instead of one of them, is also a way of checking the robustness of general findings. I also utilize three different regression techniques to check the robustness of the results. The investigation of the relationship between the Fed rate and several long-term rates by using different econometric techniques is also a cautionary measure against the drawbacks of relatively small size of sub-samples used in this paper.[5]

[5] Small sample size is always an important problem for time series macroeconomics. Admittedly, the sizes of my sub-samples are not big enough to use large sample size properties comfortably. This is especially true for the third period. This requires caution in interpreting my regression results. However, as discussed in the text, the main results of this paper are robust to different regression techniques and hold true for all relevant long-term interest rates. Therefore, we may still rely on the main results.

### C.II Three Different Regression Techniques

For my econometric analysis, as a benchmark case, I use a simple OLS (with the levels of variables). To address possible unit root problems, I utilize a simple OLS with the differences of the variables. Moreover, I utilize the General Methods of Moments (GMM) method to take care of potential endogeneity problems.

One of the most common problems in time series data is the existence of the unit root, which can cause spurious regression results. It is a well known fact that for relatively small samples the results of unit roots should be used cautiously (Bai and Ng 2004). I use an array of unit root tests (Augmented Dickey-Fuller, and Philips Perron, KPSS unit root tests) with constant, and constant and trend options. Apart from the KPSS unit root test, the null hypothesis of all these tests is that there is no unit root. Results are mixed (Appendix A.II). Whereas some variables do not have unit room problem, some others seem to have unit root problems. To address this potential problem I use the differences of the variables in the regression equations without a constant. So, the interpretations of the coefficients can be more or less the same as that in the original regression equation.

In my regression, specification of interest rates and foreign capital flows may be simultaneously determined. In other words, high-level interest rates may attract high levels of capital flows and high-level of capital flows may abate interest rates, which means that we may face endogeneity problem. Instrumental Variable (IV) or GMM techniques can be used to address this problem. I will use the GMM robust estimation method for this part to address this problem.

One crucial issue concerning IV or GMM is finding relevant instruments. The valid instruments must have high correlation with the variables considered endogenous and must be orthogonal to the errors of the original regression. Furthermore, having more valid instruments than the number of endogenous variables can produce relatively more efficient results. I use foreign official purchases of the US assets and the first difference of foreign flows as the instruments.[6] Although foreign official purchases may have high correlation with total net asset purchased by foreigners, the decisions of foreign officials are less likely to be affected by changes in US interest rates. The differences or the lag values of the variables are commonly used as instruments too. Thereby, the net foreign official purchases of the US assets and the first difference of the capital flows in the US can potentially serve as the instruments. As can be seen from the GMM regression Tables in Appendix A.VIII, these instruments successfully passed redundancy, weak identification, and orthogonality tests. Weak identification tests check for the joint significance of the instruments whereas the redundancy test investigates the individual significance of the specified instrument(s). In other words, these tests investigate if there is enough correlation between instruments and the specified endogenous variable(s). The Hansen J test is used to check the orthogonality condition. If the specified variable is endogenous, with the valid instruments, GMM estimates are more consistent and have large sample normal distribution. Although I established that our instruments are valid instruments, I still need to test the validity of endogeneity of the specified variable. I used a Durbin-Wu-Haussman type of endogeneity test which is robust to various violations of

[6] Several other instruments such as the second and third lag of foreign capital inflows, the second difference of the foreign capital inflows are also tested. However, they either failed the redundancy test or orthogonality tests.

conditional homoskedasticity (Baum 2007). All endogeneity test results unanimously show that foreign capital flows can be treated as an endogenous variable (see Tables in Appendix A. VIII).

Although OLS may not address several key econometric problems, it is well known that, especially for small samples, using other techniques like Instrumental Variable (IV), General Method of Moments (GMM), Vector Auto Regressive (VAR) or using differences in the regressions can be very costly. For example, it is crucial to estimate the optimal weighting matrix to be able to have efficient GMM results. However, this may not be possible for small sample sizes (Hayashi 2000: 215). Furthermore, as discussed, it is not easy to answer if the variables have unit root problems especially in small samples. Hence, the OLS framework would be still a reasonable starting point for our analysis.

Given the fact that all these methods have advantages and disadvantages, to be able to have a robust picture, I will report all the results obtained from different techniques. Instead of relying on the results from one of the techniques utilized in this paper, the conclusion of this section is based on the existence of the patterns in all different exercises used for the robustness checks.

### C.III. Dealing with Autocorrelation, Heteroskedasticity and Multicollinearity Problems

Regardless of the technique used for an econometric analysis, heteroskedasticity, autocorrelation and multicollinearity problems can significantly distort time series econometric results. This paper carefully addresses these issues.

As Table A.8 in appendix shows, the heteroskedasticity problem is not an issue for sub-periods although the test statistics indicate that the homoscedasticity assumption is not valid for the entire period. This finding is one of the indications that our sub periods are statistically meaningful. Autocorrelation seems to be an important problem especially for the OLS with the levels of variables and the GMM estimates (see Appendix A.III and the tables in Appendix A. VIII). To address heteroskedasticity and autocorrelation problems, I use Newey-West procedure for the OLS regressions and, autocorrelation consistent variances for the GMM regressions (as Baum et al. 2007 suggest).

Multicollinearity is one of the facts of life for many time series practitioners. Luckily, in most of the cases, my regression specifications do not suffer from multicollinearity problems (see Appendix A.V). In particular, the regression specifications with the differences do not seem to have any multicollinearity problem at all. [7]

## C.IV Basic Results

Most of the studies on this subject focus on the whole period and do not pay enough attention to the particularities of the different sub-periods. Some other studies argue that the link between the long rate and the Fed rate mainly changed after 2001. However, if we take all the findings into consideration, the clearest and most robust result

[7] However, there seems to be serious multicollinearity problems in the third period in the OLS-level and GMM regressions. The investigation of eigan values shows that the lack of variability in volatility and expected inflation causes this problem. There is no clear cut solution for multicollinearity although it can destabilize the estimates considerably. In other words, under severe multicollinearity problems, the coefficients of the variables would be very sensitive to slightly different specifications. The correlated variables can capture each other’s influence. Since, the main results obtained from OLS and GMM for the third period indicate the same pattern with the main results of the regressions with the differences (which do not have multicollinearity), I do not have to worry about this problem.

from the regression analysis in this section is that the impact of the Fed has considerably decreased since the beginning of the 1990s. [8] In other words, the decoupling between the Fed and other long-term interests is not a new phenomenon even after controlling for other influences. Table 2 below displays the coefficients of the Fed rate in the regressions for different periods with various long-term interest rates. As can be seen from Table 2, in terms of the relationship between the Fed and long rates, the period after 2001 can be, at best, considered as the continuation of the period started at the beginning of the 1990s.

Table 2: The Impact of the Fed Targeted Rate on Different Long-Term Interest Rates

| Dependent Variable | Method | Whole | Period 1 | Period 2 | Period 3 |
|---|---|---|---|---|---|
| 10-yr | Fed-OLS | 0.364*** | 0.880*** | 0.329*** | 0.078 |
| | Fed Diff | 0.373*** | 0.562*** | 0.376* | 0.072 |
| | Fed-GMM | 0.321*** | 0.845*** | 0.339*** | 0.102 |
| AAA Bond | Fed-OLS | 0.344*** | 0.48 | 0.268*** | -0.168 |
| | Fed-Diff | 0.280*** | 0.375*** | 0.315** | 0.034 |
| | Fed-GMM | 0.313*** | 0.494* | 0.267*** | -0.257* |
| BAA Bond | Fed-OLS | 0.351*** | 0.425 | 0.259** | -0.244 |
| | Fed-Diff | 0.287*** | 0.448*** | 0.268* | -0.054 |
| | Fed-GMM | 0.325*** | 0.434 | 0.247** | -0.336** |
| Mortage | Fed-OLS | 0.441*** | 0.606** | 0.362*** | 0.186 |
| | Fed-Diff | 0.416*** | 0.600*** | 0.436** | 0.156 |
| | Fed-GMM | 0.396*** | 0.594*** | 0.354*** | 0.203 |
| *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | |

This is true for all long-term interest rates used in our analysis. In the first period, the Fed variable is very high and significant. In the second period, this seems to decrease considerably in almost all the cases. In the third period, the coefficients of the Fed

[8] The full tables of the estimation can be seen in Appendix A.VI, A.VII and A.VIII

variable are either insignificant or significant with the wrong sign. For example, the coefficient of the Fed in the OLS regression of 10-year Treasury bond is 0.880, 0329 and 0.078 (insignificant) in the first, second and third periods respectively.

The second important finding of this section is that capital flows seem to have had a significant impact especially on mortgage rates. The capital flow variable is also significant in the regression of AAA and BAA with differences. It has correct sign in almost all other cases in the third period (see Table 3).

Table 3: The Impact of the Financial Flows on Long-Term Interest Rates

| Dependent Variable | Method | Whole | Period 1 | Period 2 | Period 3 |
|---|---|---|---|---|---|
| 10-Yr | OLS | -0.146 | 0.004 | 0.138 | -0.027 |
| | Diff | -0.027 | 0.058 | -0.002 | -0.057 |
| | GMM | 0.013 | 0.191 | 0.078 | -0.055 |
| AAA Bond | OLS | -0.310*** | 0.14 | 0.092 | -0.053 |
| | Diff | -0.042 | 0.045 | -0.027 | -0.071** |
| | GMM | -0.108 | 0.034 | 0.099 | -0.024 |
| BAA Bond | OLS | -0.285** | 0.156 | 0.072 | -0.037 |
| | Diff | -0.041 | 0.036 | -0.04 | -0.069* |
| | GMM | -0.078 | 0.074 | 0.182 | 0.002 |
| MRTG | OLS | -0.202* | 0.048 | 0.043 | -0.110*** |
| | Diff | -0.071** | 0.048 | -0.087 | -0.104*** |
| | GMM | -0.01 | 0.133 | 0.102 | -0.134** |

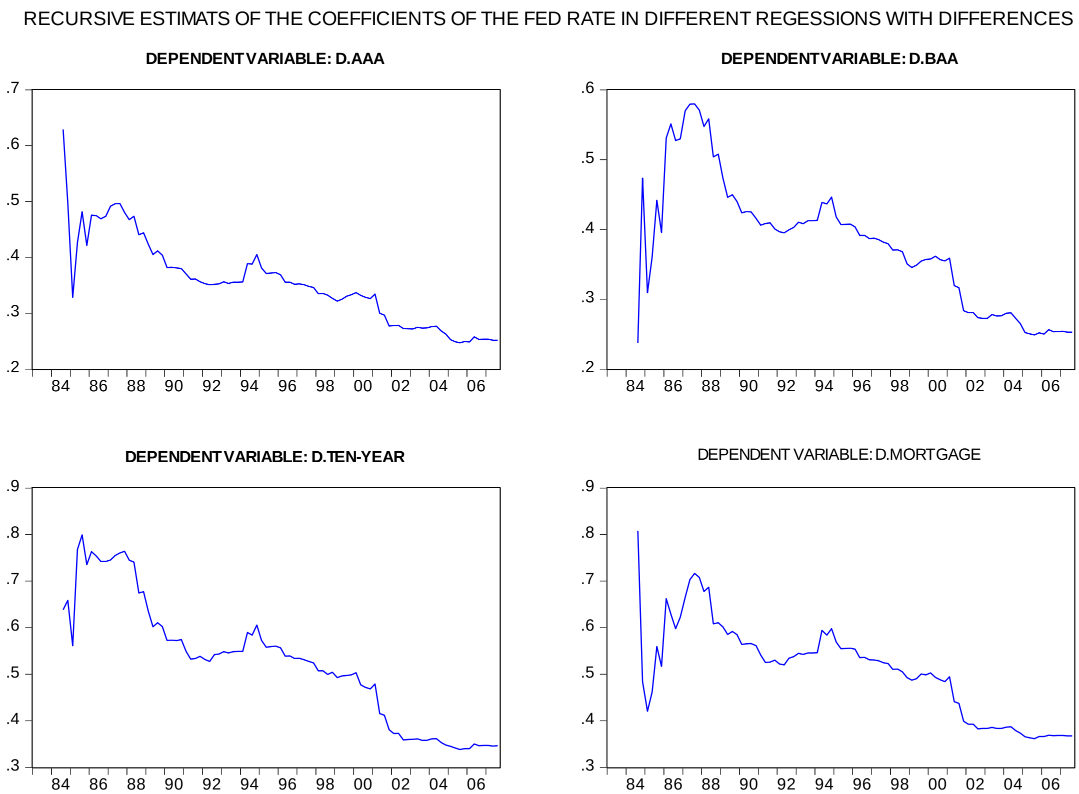
*** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level.

## C.V The Results from Rolling Regressions

I also investigate how the coefficients of the Fed rate have evolved throughout the period under investigation by using rolling regression coefficients. Although the rolling regression results may not be taken at their face value, they can shed some light on the relationship between the Fed and long-term interest rates.

The coefficients graphed below were obtained from the equation estimated repeatedly, using larger and larger sub-sample data set. The first estimate of the coefficient was calculated from the regression equation with the first 6 observations. Then, the next estimate of the coefficient was obtained from the equation with 7 observations. To obtain the other estimates this process was repeated until all the observations were used.[9] Figure 3 displays the rolling coefficients of the Fed variable in the equation 3 when the differences of the variables are used in the regression.

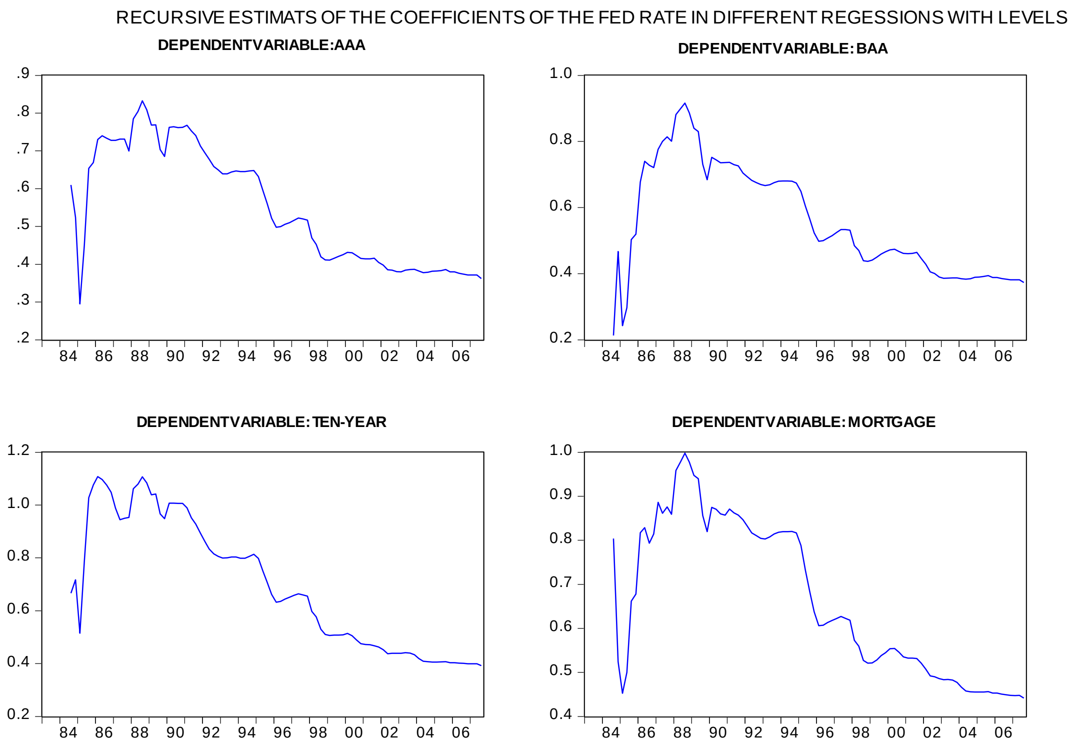
Figure 3:Recursive Estimates (Differences)




[9] Since this approach is based on estimating coefficients with more and more observations, the marginal impact of last observations in the third period may not be very apparent. In other words, after a certain point, the slope of curve may decrease. Therefore, the relative flattening of the curve in the last period cannot be seen as an indication of a substantial decrease in the deterioration of the relationship between the Fed rate and long-rates. In fact, when one considers the findings of recursive estimates together with the findings of the other sections, the gradual decoupling between the Fed rate and long-rates are obvious.

As can be seen from the graph, the responsiveness of the long rates has gradually decreased since the beginning of the 1990s. This is more evidence for the claim that the decoupling between the Fed rate and long rates began around 1990. Figure 4 displaying the rolling coefficients of the Fed variable in the equation 3 when the levels of the variables are used in the regression further lends support to this claim. Overall both recursive estimates and different regression techniques robustly support the claim that there has been a decoupling between the Fed rate and long-rates.

Figure 4: Recursive Estimates (Levels)




## D. Conclusion and Discussions

This paper investigates the relationship between overnight interest rates and long-term interest rates and movements of long rates in the US from 1983q1 to 2007q3. It presents evidence that the Fed has been gradually losing its control over long-term interest rates. As opposed to many economists' claims, the period after 2001 is a continuation of a process which has began at the end of the 1980s. Both descriptive statistics and different econometric techniques robustly support this finding. Furthermore, the purchase of the US assets might have played some roles in this process although the findings concerning this are not very robust.

There are two main implications of the findings of the paper. First, using overnight interest rates may not be sufficient to direct developments in an economy. As discussed before, central banks may affect output and inflation mainly via interest rate channel or credit channel. However, the success of interest rate channel depends on several strong conditions to hold true simultaneously. In light of my findings, it appears that the usefulness of the interest rate channel has decreased with the decoupling between the Fed rate and long-term interest rates. Furthermore, as discussed in the first paper, there are a lot of reasons to believe that the influence of the Fed over quantities of financial markets have decreased significantly. As a result, in a situation in which the Fed rate may not affect financial quantities and prices considerably, the overnight interest rate policy framework should be reconsidered.

Second, models based on the idea that central banks may exert great influence on economies by controlling overnight interest should be reconsidered. Almost all current macro-economic models are based on the assumption that central banks can exert great influence on long-term interest rates. Nowadays, with some modifications, most economists share similar ideas. There seems to be a New Consensus about monetary economics (Clarida, Gali and Gertler 1999, Romer 2000, McCallum 2001, Woodford 2003). Interestingly, several Post-Keynesian models use similar frameworks, though these models do not accept the long-run neutrality of monetary policy (Lavoie 2005 and Setterfield 2005). This paper implies that these models may not be very suitable to understand macroeconomic events and the role of central banking in an economy.

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**APPENDIX : Data Description and Extra Tables**

**Appendix A.I: Data Description**

The data used in this paper was obtained from several different sources. Fed monthly and quarterly targeted rates were established by calculating the monthly and quarterly simple average daily targeted Fed rates available on the St Louis Fed's web page. AAA Bond, BAA Bond, Mortgage and 10-year Treasury bond interest rates are originally monthly which are available on the St Louis Fed's web page. Quarterly data sets were obtained by calculating the simple quarterly average of the monthly data sets. One year ahead expected growth data is found in the Survey of Professional Forecasters (SPF). Risk premium was calculated as the 12-quarter moving average of the standard deviation of related long-term interest rates. The 10-year long-term inflation forecast represents long-term expected inflation. It is very difficult to find reliable long-term expected inflation data, even in the US. One major source for long-term expectations is the Survey of Professional Forecasters (SPF) which is conducted by the Federal Reserve Bank of Philadelphia on a quarterly basis. For the period of 1991:4 to 2007:3, ten year Consumer Price Inflation (CPI) forecasts from this source can be directly used. However, for the preceding period, there is no quarterly data for 10 year long-term CPI forecasts.[10] Hence, to be able to use consistent data, long-term inflation expectations were derived from a 12-quarter simple moving average of annual CPI forecasts. Deriving long-term inflation expectations from the moving average of annual inflation forecasts seems to reasonable, given the fact that, after the 1990s, the simple correlation between 10 year long-term CPI forecasts obtained from 12 quarters moving average of annual CPI expectation and 10 year CPI expectation available is 0.94. Furthermore, this method can increase the variability in long-term expectations which the original data lacks. [11]

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[10] Livingstone index published by Philadelphia Federal Reserve has semi-annual 10 year ahead expected inflation series.

[11] Variability in regressors is an important issue for two reasons. First, the coefficients of those variables which do not have high variability can unexpectedly large due to the sensitivity of the regression to any

I measure capital inflows by using net total US assets purchased by foreigners. The date source is US International Transactions data set (Table 1) of Bureau of Economic Analysis which is available online. This measure reflects total availability of foreign funds in the US. The data set used in my analysis includes financial derivatives after 2006 although the results of the regression do not change even if I exclude financial derivatives from the data set.

Table A.1: Key for the Variables in the Tables in the Main Text and Appendix

| | |
|---|---|
| AAA | AAA Corporate Bond Rate |
| BAA | BAA Corporate Bond Rate |
| TENYR | 10-yr Treasury Bond Rate |
| MRTG | 30-year Fixed Mortgage Rate |
| FED | The Federal Reserve Rate |
| EXPGR | Expected Growth |
| EXPINF | Expected Inflation |
| VOLAAA | Volatility of AAA Corporate Bond Rate |
| VOLBAA | Volatility of BAA Corporate Bond Rate |
| VOLMRTG | Volatility of the Mortgage Rate |
| FLOW | Net Purchase of US Assets by Foreigners |

changes in those variables. Second, in a regression equation with constant term those variables displaying less variability can cause severe multicollinearity problems.

## Appendix A.II: Unit Root Tests

Table A.2: DFGLS Unit Root Statistics

| | | Whole | | Period1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend |
| | Test Statistic | 0.26 | -2.686 | -1.257 | -1.927 | -0.905 | *-3.661* | -0.396 | -2.085 |
| | 5% Critical Value | -2.092 | -3.039 | -2.513 | -3.443 | -2.271 | -3.336 | -2.612 | -3.505 |
| AAA | 10% Critical Value | -1.789 | -2.747 | -2.175 | -3.084 | -1.965 | -3.011 | -2.18 | -3.146 |
| | Test Statistic | 0.309 | -1.857 | -0.785 | -1.708 | -0.848 | *-3.108* | *-3.16* | -2.649 |
| | 5% Critical Value | -2.129 | -3.039 | -2.513 | -3.443 | -2.406 | -3.336 | -3.839 | -4.084 |
| BAA | 10% Critical Value | -1.823 | -2.747 | -2.175 | -3.084 | -2.095 | -3.011 | -3.054 | -3.139 |
| | Test Statistic | *0.482* | *-3.924* | -1.681 | -2.078 | 0.664 | *-3.305* | -2.037 | -2.751 |
| | 5% Critical Value | -1.986 | -3 | -2.513 | -3.443 | -2.203 | -2.757 | -2.544 | -3.505 |
| TENYR | 10% Critical Value | -1.687 | 2.711 | -2.175 | -3.084 | -1.857 | -2.428 | -2.207 | -3.146 |
| | Test Statistic | 0.419 | -1.372 | -0.834 | -1.521 | -1.005 | *-3.349* | -2.869 | -2.319 |
| | 5% Critical Value | -1.986 | -2.808 | -2.439 | -3.391 | -2.271 | -3.336 | -3.839 | 3.505 |
| MRTG | 10% Critical Value | -1.687 | -2.532 | -2.125 | -3.061 | -1.965 | -3.011 | -3.054 | -3.146 |
| | Test Statistic | -1.562 | *3.679* | *-2.1* | *3.446* | *-3.221* | *-3.437* | *-3.217* | -0.476 |
| | 5% Critical Value | -2.078 | 2.952 | -2.303 | -2.843 | -2.406 | -2.757 | -2.531 | -4.084 |
| FED | 10% Critical Value | -1.776 | -2.668 | -1.956 | -2.443 | -2.095 | -2.428 | -2.032 | -3.139 |
| | Test Statistic | -1.29 | -1.681 | 0.197 | -1.227 | -1.926 | -1.941 | -0.526 | -2.973 |
| | 5% Critical Value | -2.048 | -2.898 | -2.303 | -2.958 | -2.345 | -3.287 | -2.544 | -3.505 |
| EXPGR | 10% Critical Value | -1.748 | -2.617 | -1.956 | -2.607 | -2.04 | -2.973 | -2.207 | -3.146 |

Optimal Lag is chosen according to Ng-Perron Sequential t statistics. In general, Ng-Peron Sequential Statistics and Minc SC and Min MAIC show consistent results. Whenever both Min SC and Min MAIC disagree with Ng-Perron Sequential t statistics in choosing optimal lags, one of them is used as criterion. The null hypothesis: Variable is not stationary. Those cells underlined and italicized indicate that null hypothesis is rejected at least at the 10 percent significance level.

Table A.2: DFGLS Unit Root Statistics (Continued)

| | | Whole | | Period1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend |
| EXPECINF | Test Statistic | 0.858 | -1.649 | -1.319 | *-3.343* | -0.119 | *-3.492* | -2.635 | *-3.284* |
| | 5% Critical Value | -1.986 | -2.776 | -2.45 | -3.443 | -2.406 | *-3.336* | -3.839 | -4.084 |
| | 10% Critical Value | -1.687 | -2.502 | -2.116 | *-3.084* | -2.095 | *-3.011* | -3.054 | *-3.139* |
| VOLAAA | Test Statistic | -0.121 | -1.817 | -2.087 | *-3.207* | -1.244 | -1.538 | -0.954 | *-3.755* |
| | 5% Critical Value | -2.064 | -2.926 | -2.513 | -3.443 | -2.364 | -3.262 | -3.839 | -3.143 |
| | 10% Critical Value | -1.762 | -2.643 | -2.175 | -3.084 | -2.056 | -2.943 | -3.054 | -2.705 |
| VOLBAA | Test Statistic | -0.05 | *-3.841* | 0.316 | *-3.574* | *-2.064* | -2.096 | *-4.601* | *-4.695* |
| | 5% Critical Value | -2.064 | -3.039 | -2.306 | -3.2 | -2.364 | -3.262 | -2.444 | -3.143 |
| | 10% Critical Value | -1.762 | -2.747 | -1.944 | -2.856 | -2.056 | -2.943 | -2.007 | -2.705 |
| VOLTENYR | Test Statistic | 0.191 | -2.935 | -1.71 | -2.935 | -1.449 | -1.653 | -1.102 | *-2.838* |
| | 5% Critical Value | -2.6 | -3.336 | -2.652 | -3.039 | -2.638 | -3.262 | -2.544 | -3.009 |
| | 10% Critical Value | -2.017 | -3.011 | -2.513 | -2.747 | -2.364 | -2.943 | -2.207 | -2.548 |
| VOLMRTG | Test Statistic | -0.234 | -2.534 | -1.289 | *-3.189* | -1.531 | -1.57 | -1.161 | -2.274 |
| | 5% Critical Value | -2.092 | -3.039 | -2.513 | -3.443 | -2.364 | -3.262 | -2.612 | -3.521 |
| | 10% Critical Value | -1.789 | -2.747 | -2.175 | -3.084 | -2.056 | -2.943 | -2.18 | -3.075 |

Optimal Lag is chosen according to Ng-Perron Sequential t statistics. In general, Ng-Peron Sequential Statistics and Minc SC and Min MAIC agree on the results. Whenever both Min SC and Min MAIC disagree with Ng-Perron Sequential t statistics in choosing optimal lags, one of them is used as criterion. The null hypothesis: Variable is not stationary. Those cells underlined and italicized indicate that the null hypothesis is rejected at least at the 10 percent significance level.

Table A.3: DFGLS Unit Root Statistics (Differences)

| | | Whole | | Period1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend |
| AAA | Test Statistic | -5.226 | -5.268 | -4.178 | -4.204 | -4.081 | -4.128 | -5.212 | -4.71 |
| | 5% Critical Value | -2.106 | -3 | -2.439 | -3.391 | -2.317 | -3.175 | -2.544 | -3.009 |
| | 10% Critical Value | -1.802 | -2.711 | -2.125 | -3.061 | -2.011 | -2.861 | -2.207 | -2.548 |
| BAA | Test Statistic | *-1.056* | -6.99 | -3.827 | -3.984 | -3.922 | -4.337 | -4.769 | -3.217 |
| | 5% Critical Value | -2.048 | -3.032 | -2.439 | -3.391 | -2.345 | -3.287 | -2.544 | -3.521 |
| | 10% Critical Value | 1.748 | -2.74 | -2.125 | -3.061 | -2.04 | -2.973 | -2.207 | -3.075 |
| TENYR | Test Statistic | -4.801 | -5.075 | -3.693 | -3.693 | -3.923 | -3.842 | -3.101 | -5.194 |
| | 5% Critical Value | -2.017 | -2.839 | -2.439 | -3.391 | -2.18 | -2.757 | -3.192 | *-3.505* |
| | 10% Critical Value | -1.718 | -2.562 | -2.125 | -3.061 | -1.85 | -2.428 | -2.535 | -3.146 |
| MRTG | Test Statistic | *-0.019* | -4.653 | -4.126 | -4.665 | -4.128 | -4.072 | -4.046 | -4.524 |
| | 5% Critical Value | -1.986 | -3.039 | -2.439 | -3.391 | -2.317 | -3.175 | -2.436 | -3.009 |
| | 10% Critical Value | -1.687 | -2.747 | -2.125 | -3.061 | -2.011 | -2.861 | -1.977 | -2.548 |
| FED | Test Statistic | -1.562 | -3.679 | -2.1 | -3.446 | -3.221 | -3.446 | -3.217 | *-0.476* |
| | 5% Critical Value | -2.078 | -2.952 | -2.303 | -2.843 | -2.406 | -2.898 | -2.531 | -4.084 |
| | 10% Critical Value | -1.776 | -2.668 | -1.956 | -2.443 | -2.095 | -2.617 | -2.032 | -3.139 |
| EXPGR | Test Statistic | *-1.365* | -8.518 | -3.241 | -4.237 | -8.364 | -8.8 | -6.276 | -7.344 |
| | 5% Critical Value | -2.064 | -3.039 | -2.334 | -3.071 | 2.345 | -3.27 | -2.544 | -3.505 |
| | 10% Critical Value | -1.762 | -2.747 | -1.996 | -2.727 | -2.04 | -2.98 | -2.207 | -3.146 |

Optimal Lag is chosen according to Ng-Perron Sequential t statistics. In general, Ng-Peron Sequential Statists and Minc SC and Min MAIC agree on the results. Whenever both Min SC and Min MAIC disagree with Ng-Perron Sequential t statistics in choosing optimal lags, one of them is used as criterion. The null hypothesis: Variable is not stationary. Those cells underlined and italicized indicate that null hypothesis is **NOT** rejected at least at the 10 percent significance level.

Table A.3: DFGLS Unit Root Statistics (Differences-Continued)

| | | Whole | | Period1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend |
| EXPECINF | Test Statistic | *0.22* | *-1.117* | *-1.01* | *-1.417* | *-1.966* | *-2.383* | *-1.555* | *-2.383* |
| | 5% Critical Value | -2.002 | -2.808 | -2.513 | -3.443 | -2.345 | -3.287 | -2.544 | -3.287 |
| | 10% Critical Value | -1.703 | -2.532 | -2.175 | -3.084 | -2.04 | -2.973 | -2.207 | -2.973 |
| VOLAAA | Test Statistic | -2.95 | -3.221 | -2.688 | -3.491 | -4.816 | -4.97 | *-0.737* | -2.573 |
| | 5% Critical Value | -2.513 | -2.977 | -2.387 | -2.958 | -2.406 | -3.336 | -3.192 | -3.009 |
| | 10% Critical Value | -2.175 | -2.69 | -2.053 | -2.607 | -2.095 | -3.011 | -2.535 | -2.548 |
| VOLBAA | Test Statistic | *-2.834* | -4.323 | -2.156 | -4.582 | -4.657 | -4.408 | -2.184 | *-2.344* |
| | 5% Critical Value | *-2.129* | -3.039 | -2.439 | -2.958 | -2.406 | -3.336 | -2.444 | -3.143 |
| | 10% Critical Value | -1.823 | -2.747 | -2.125 | -2.607 | -2.095 | -3.011 | -2.007 | -2.705 |
| VOLTENYR | Test Statistic | -2.13 | -3.951 | *-2.146* | -3.199 | -3.883 | -4.502 | -2.236 | -4.502 |
| | 5% Critical Value | -2.129 | 3.039 | -3.287 | -2.958 | -2.406 | -3.336 | -2.406 | -3.336 |
| | 10% Critical Value | *-1.823* | -2.747 | -2.973 | -2.607 | -2.095 | -3.011 | -2.18 | -3.011 |
| VOLMRTG | Test Statistic | -1.999 | -3.744 | *-2.142* | -2.439 | -4.123 | -4.201 | -2.889 | -2.957 |
| | 5% Critical Value | -2.129 | -3.443 | -2.439 | -2.23 | -2.406 | -3.336 | -2.544 | -3.505 |
| | 10% Critical Value | -1.823 | -3.084 | -2.439 | -1.922 | -2.095 | -3.011 | -2.207 | -3.146 |

Optimal Lag is chosen according to Ng-Perron Sequential t statistics. In general, Ng-Peron Sequential Statics and Minc SC and Min MAIC agree on the results. Whenever both Min SC and Min MAIC disagree with Ng-Perron Sequential t statistics in choosing optimal lags, one of them is used as criterion. Null Hypothesis: Variable is not stationary. Those cells underlined and italicized indicate that the null hypothesis is **NOT** rejected at least at the 10 percent significance level.

Table A.4: Phillips-Perron test Statistics

| | Whole | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | Constant | Constant&Trend | Constant | Constant&Trend | Constant | Constant&Trend | Constant | Constant&Trend |
| AAA | 0.48 | 0.22 | 0.68 | 0.73 | 0.15 | 0.43 | *0.07* | 0.67 |
| BAA | 0.21 | 0.24 | 0.56 | 0.73 | 0.56 | 0.42 | 0.28 | 0.94 |
| TENYR | 0.49 | 0.16 | 0.62 | 0.70 | 0.19 | 0.26 | 0.26 | 0.48 |
| MRTG | 0.21 | 0.27 | 0.53 | 0.77 | 0.09 | 0.30 | 0.30 | 0.75 |
| FED | 0.33 | 0.61 | 0.44 | 0.79 | 0.42 | 0.23 | 0.97 | 0.52 |
| EXPGR | 0.00 | 0.02 | 0.06 | 0.02 | 0.37 | 0.86 | 0.95 | 0.39 |
| EXPINF | *0.07* | 0.55 | *0.06* | 0.44 | 0.18 | 0.74 | 0.85 | 0.19 |
| VOLAAA | 0.13 | 0.12 | 0.55 | 0.55 | 0.27 | 0.61 | 0.66 | 0.43 |
| VOLBAA | 0.14 | *0.08* | 0.49 | 0.39 | 0.23 | 0.40 | 0.54 | 0.82 |
| VOLTENYR | 0.26 | 0.18 | 0.66 | 0.52 | 0.25 | 0.58 | 0.52 | 0.68 |
| VOLMRTG | 0.12 | 0.14 | 0.61 | 0.41 | 0.33 | 0.54 | 0.56 | 0.79 |

MacKinnon approximate p-value for Z(t), Null Hypothesis: Variable is not stationary. Those cells underlined and italicized indicate that null hypothesis is rejected at least at the 10 percent significance level.

Table A.5: Phillips-Perron test Statistics (Differences)

| | Whole | | Period1 | | Period2 | | Period3 | |
|---|---|---|---|---|---|---|---|---|
| | Constant | Constant&Trend | Constant | Constant&Trend | Constant | Constant&Trend | Constant | Constant&Trend |
| AAA | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 |
| BAA | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| TENYR | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| MRTG | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FED | 0.00 | 0.00 | 0.01 | 0.05 | 0.00 | 0.04 | 0.00 | 0.03 |
| EXPGR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EXPINF | 0.00 | 0.02 | *0.21* | *0.85* | *0.19* | *0.39* | *0.44* | *0.82* |
| VOLAAA | 0.00 | 0.00 | 0.10 | *0.29* | 0.02 | 0.08 | 0.02 | 0.07 |
| VOLBAA | 0.00 | 0.00 | 0.02 | 0.09 | 0.02 | 0.08 | 0.08 | *0.21* |
| VOLTENYR | 0.00 | 0.00 | 0.11 | 0.32 | 0.01 | 0.03 | 0.00 | 0.01 |
| VOLMRTG | 0.00 | 0.00 | 0.02 | 0.09 | 0.00 | 0.02 | 0.03 | 0.11 |

MacKinnon approximate p-value for Z(t), Null Hypothesis: Variable is not stationary. Those cells underlined and italicized indicate that the null hypothesis is rejected at least at the 10 percent significance level.

Table A.6: KPSS Unit Root Test Statistics

| | | Whole | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend |
| AAA | Test Statistic | *2.19* | 0.22 | 0.76 | 0.15 | 0.52 | 0.09 | 0.49 | 0.18 |
| BAA | Test Statistic | *2.17* | *0.32* | *0.85* | 0.14 | 0.54 | 0.14 | 0.53 | 0.21 |
| TENYR | Test Statistic | *2.16* | 0.18 | 0.65 | 0.14 | 0.57 | 0.05 | 0.28 | 0.13 |
| MRTG | Test Statistic | *2.19* | *0.31* | *0.81* | 0.16 | 0.39 | 0.08 | 0.19 | 0.18 |
| FED | Test Statistic | *1.48* | 0.11 | 0.28 | 0.19 | 0.51 | 0.51 | 0.73 | 0.18 |
| EXPGR | Test Statistic | 0.56 | 0.23 | 0.67 | 0.11 | 0.26 | 0.22 | *0.76* | 0.18 |
| EXPINF | Test Statistic | *2.37* | 0.23 | 0.29 | *0.24* | *1.02* | 0.08 | 0.61 | 0.16 |
| VOLAAA | Test Statistic | *1.20* | 0.20 | 0.45 | 0.11 | 0.14 | 0.14 | 0.54 | 0.10 |
| VOLBAA | Test Statistic | *1.32* | 0.20 | 0.52 | 0.08 | 0.30 | 0.13 | 0.21 | 0.15 |
| VOLTENYR | Test Statistic | *1.39* | 0.20 | 0.57 | 0.13 | 0.15 | 0.14 | 0.63 | 0.12 |
| VOLMRTG | Test Statistic | *1.14* | 0.19 | 0.65 | 0.08 | 0.34 | 0.14 | 0.56 | 0.14 |
| Critical Values | 5% Critical Value | 0.46 | 0.15 | 0.46 | 0.15 | 0.46 | 0.15 | 0.463 | 0.146 |
| | 1% Critical Value | 0.74 | 0.22 | 0.74 | 0.22 | 0.74 | 0.22 | 0.739 | 0.216 |

Null Hypothesis: Variable is stationary. Maximum lag is chosen by Schwert criterion. Those cells underlined and italicized indicate that the null hypothesis is rejected at the 1 percent significance level.

Table A.7: KPSS Unit Root Test Statistics (Differences)

| | | Whole | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant &Trend | Constant | Constant& Trend |
| AAA | Test Statistic | 0.07 | 0.03 | 0.12 | 0.11 | 0.10 | 0.04 | 0.34 | 0.05 |
| BAA | Test Statistic | 0.17 | 0.03 | 0.12 | 0.07 | 0.20 | 0.04 | 0.34 | 0.06 |
| TENYR | Test Statistic | 0.05 | 0.03 | 0.11 | 0.11 | 0.06 | 0.04 | 0.14 | 0.07 |
| MRTG | Test Statistic | 0.18 | 0.03 | 0.14 | 0.08 | 0.10 | 0.04 | 0.29 | 0.07 |
| FED | Test Statistic | 0.11 | 0.05 | 0.11 | 0.08 | 0.25 | 0.12 | 0.38 | 0.18 |
| EXPGR | Test Statistic | 0.11 | 0.08 | 0.07 | 0.04 | 0.31 | 0.10 | 0.18 | 0.06 |
| EXPINF | Test Statistic | 0.40 | 0.09 | 0.50 | 0.18 | 0.29 | 0.11 | 0.44 | 0.19 |
| VOLAAA | Test Statistic | 0.03 | 0.02 | 0.08 | 0.06 | 0.12 | 0.10 | 0.19 | 0.12 |
| VOLBAA | Test Statistic | 0.02 | 0.02 | 0.08 | 0.06 | 0.16 | 0.10 | 0.19 | 0.08 |
| VOLTENYR | Test Statistic | 0.03 | 0.03 | 0.10 | 0.06 | 0.11 | 0.07 | 0.10 | 0.07 |
| VOLMRTG | Test Statistic | 0.04 | 0.04 | 0.06 | 0.06 | 0.13 | 0.10 | 0.11 | 0.07 |
| Critical Values | 5% Critical Value | 0.46 | 0.15 | 0.46 | 0.15 | 0.46 | 0.15 | 0.46 | 0.15 |
| | 1% Critical Value | 0.74 | 0.22 | 0.74 | 0.22 | 0.74 | 0.22 | 0.74 | 0.22 |

Null Hypothesis: Variable is stationary. Maximum lag is chosen by Schwert criterion. Those cells underlined and italicized indicate that null hypothesis is rejected at the 1 percent significance level. KPSS test results suggests that the first differences of all the variables in this table are stationary

## **Appendix A.III: Heteroskedasticity Statistics**

Table A.8: Heteroskedasticity Tests

| Dependent Variable | Method | Whole | Period1 | Period 2 | Period 3 |
|---|---|---|---|---|---|
| TENYR | OLS | *0.00* | 0.91 | 0.32 | 0.72 |
| | Diff | *0.02* | 0.40 | 0.61 | 0.43 |
| | GMM | *0.00* | 0.80 | 0.33 | 0.20 |
| AAA | OLS | *0.00* | 0.39 | 0.24 | 0.57 |
| | Diff | *0.00* | 0.50 | 0.66 | 0.43 |
| | GMM | *0.00* | 0.12 | 0.12 | 0.91 |
| BAA | OLS | *0.00* | *0.00* | 0.13 | 0.97 |
| | Diff | *0.00* | 0.14 | 0.53 | 0.37 |
| | GMM | *0.01* | 0.13 | 0.20 | 0.93 |
| MRTG | OLS | *0.00* | 0.64 | 0.53 | 0.55 |
| | Diff | *0.01* | 0.19 | 0.82 | 0.31 |
| | GMM | *0.00* | 0.11 | 0.15 | 0.15 |

The statistics reported are p values. Null Hypotheses: Disturbances are homoskedastic. Breusch-Pagan/Cook-Weisberg test, White's test and Pagan-Hall general test are used for OLS-levels of the variables, OLS-differences and GMM regressions respectively. Those cells underlined and italicized indicate that the null hypothesis is rejected at the 1 percent significance level.

## Appendix A.IV: Autocorrelation Test Tables

Table A.9: Auto Correlation Statistics based on Breusch-Godfrey LM Test up to 5 lags

| Dependent Variable | Method | Whole | | | | | Period 1 | | | | | Period 2 | | | | | Period 3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TENYR | OLS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.076 | 0.15 | 0.262 | 0.02 | 0.035 |
| | Diff | 0.06 | 0.18 | 0.21 | 0.01 | 0.02 | 0.26 | 0.4 | 0.47 | 0.53 | 0.61 | 0.08 | 0.17 | 0.32 | 0.05 | 0.04 | 0.97 | 0.64 | 0.62 | 0.05 | 0.1 |
| AAA | OLS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.03 | 0.02 | 0 | 0 |
| | Diff | 0.13 | 0.22 | 0.33 | 0.03 | 0.06 | 0.61 | 0.62 | 0.39 | 0.43 | 0.56 | 0.01 | 0.03 | 0.06 | 0.02 | 0.02 | 0.82 | 0.96 | 0.89 | 0.28 | 0.24 |
| BAA | OLS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.03 | 0.03 | 0 | 0 |
| | Diff | 0.04 | 0.11 | 0.22 | 0.12 | 0.07 | 0.14 | 0.34 | 0.47 | 0.6 | 0.74 | 0.03 | 0.09 | 0.14 | 0.06 | 0.04 | 0.81 | 0.95 | 0.99 | 0.51 | 0.14 |
| MRTG | OLS | 0.02 | 0.07 | 0.11 | 0.09 | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 | 0.07 | 0.12 | 0.01 | 0.02 |
| | Diff | 0.41 | 0.61 | 0.78 | 0.47 | 0.16 | 0.9 | 0.9 | 0.96 | 0.83 | 0.91 | 0.19 | 0.43 | 0.57 | 0.1 | 0.05 | 0.85 | 0.83 | 0.73 | 0.06 | 0.04 |

Null Hypothesis: No Serial Autocorrelation. P values are reported (Prob > $chi^2$).

Table A.10: Autocorrelation Statistics based on Breusch-Godfrey LM Test up to 5 lags for Dynamic Regression Specifications

| Dependent Variable | Method | Whole | | | | | Period1 | | | | | Period2 | | | | | Period3 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TENYR | OLS | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.07 | 0.12 | 0.13 | 0.14 | 0 | 0 | 0 | 0 | 0 | 0.51 | 0.05 | 0.1 | 0.01 | 0.02 |
| | Diff | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0.03 | 0.06 | 0.2 | 0.44 | 0.64 | 0.16 | 0.09 | 0.13 | 0.04 | 0.08 | 0.03 | 0.04 |
| AAA | OLS | 0 | 0.02 | 0.02 | 0 | 0 | 0.1 | 0.19 | 0.13 | 0.1 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0.69 | 0.86 | 0.83 | 0.02 | 0.01 |
| | Diff | 0.4 | 0.55 | 0.32 | 0.16 | 0.19 | 0.02 | 0.05 | 0.08 | 0.15 | 0.23 | 0.1 | 0.2 | 0.36 | 0.16 | 0.08 | 0.05 | 0.12 | 0.09 | 0.16 | 0.17 |
| BAA | OLS | 0 | 0.01 | 0.03 | 0.01 | 0 | 0.04 | 0.13 | 0.16 | 0.19 | 0.16 | 0 | 0.01 | 0.02 | 0.03 | 0.01 | 0.77 | 0.73 | 0.89 | 0.07 | 0.01 |
| | Diff | 0.31 | 0.59 | 0.35 | 0.32 | 0.09 | 0 | 0.01 | 0.02 | 0.04 | 0.07 | 0.4 | 0.59 | 0.74 | 0.39 | 0.1 | 0.12 | 0.2 | 0.28 | 0.33 | 0.1 |
| MRTG | OLS | 0 | 0 | 0 | 0 | 0 | 0.3 | 0.58 | 0.77 | 0.88 | 0.28 | 0.02 | 0.01 | 0.01 | 0.01 | 0 | 0.64 | 0.19 | 0.34 | 0.01 | 0.01 |
| | Diff | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0.15 | 0.25 | 0.43 | 0.2 | 0.22 | 0.05 | 0.13 | 0.2 | 0.06 | 0.02 | 0.13 | 0.04 | 0.08 | 0.03 | 0.04 |

Nul Hypothesis: No Serial Autocorrelation. P Values are reported (Prob > $chi^2$)

## Appendix A.V : Multicollinearity Test Results

Table A.11: Variance Inflation Factors for OLS Regressions

| Dependent Variable | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | Expinf | 6.17 | Expinf | 8.21 | Expinf | 2.46 | Fed | 16.91 |
| | Fed | 3.98 | Fed | 3.67 | Flow | 2.41 | Expgr | 10.78 |
| | Flow | 2.24 | Expgr | 3.56 | Fed | 1.47 | Volaaa | 3.29 |
| | Expgr | 1.76 | Volaaa | 2.52 | Volaaa | 1.11 | Flow | 1.75 |
| AAA | Volaaa | 1.73 | Flow | 1.68 | Expgr | 1.08 | Expinf | 1.25 |
| | Expinf | 6.65 | Expinf | 7.23 | Flow | 2.41 | Fed | 18.49 |
| | Fed | 4 | Expgr | 3.52 | Expinf | 2.38 | Expgr | 12.01 |
| | Flow | 2.27 | Fed | 2.88 | Fed | 1.72 | Vobaa | 3.14 |
| | Vobaa | 1.95 | Vobaa | 2.01 | Vobaa | 1.38 | Flow | 2.1 |
| BAA | Expgr | 1.76 | Flow | 1.61 | Expgr | 1.13 | Expinf | 1.5 |
| | Expinf | 6.21 | Expinf | 7.86 | Expinf | 2.52 | Fed | 16.39 |
| | Fed | 3.97 | Expgr | 3.53 | Flow | 2.44 | Expgr | 10.38 |
| | Flow | 2.22 | Fed | 3.52 | Fed | 1.54 | Voltenyr | 4.76 |
| | Voltenyr | 1.86 | Voltenyr | 2.45 | Voltenyr | 1.13 | Expinf | 2.73 |
| TENYR | Expgr | 1.75 | Flow | 1.64 | Expgr | 1.05 | Flow | 1.8 |
| | Expinf | 6.96 | Expinf | 9.57 | Flow | 2.42 | Fed | 16.1 |
| | Fed | 4.02 | Expgr | 3.57 | Expinf | 2.39 | Expgr | 10.83 |
| | Volmrtg | 2.26 | Fed | 3.17 | Fed | 1.46 | Volmrtg | 4.32 |
| | Flow | 2.25 | Volmrtg | 3.03 | Volmrtg | 1.12 | Expinf | 3.27 |
| MRTG | Expgr | 1.82 | Flow | 1.67 | Expgr | 1.08 | Flow | 1.81 |
| Variance inflation factors greater than 10 would indicate a multicollinearity problem. | | | | | | | | |

Table A.12: Variance Inflation Factors for OLS Regressions with Differences

| Dependent Variable | Whole | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | D.Expgr | 1.17 | D.Expgr | 1.5 | D.expinf | 1.2 | D.Fed | 1.54 |
| | D.Fed | 1.16 | D.Fed | 1.4 | D.volaaa | 1.1 | D.Volaaa | 1.39 |
| | D.Flow | 1.06 | D.Flow | 1.3 | D.Fed | 1.1 | D.Expgr | 1.36 |
| | D.Volaaa | 1.04 | D.Volaaa | 1.1 | D.Flow | 1 | D.expinf | 1.18 |
| AAA | D.expinf | 1.03 | D.expinf | 1.1 | D.Expgr | 1 | D.Flow | 1.02 |
| | D.Expgr | 1.17 | D.Expgr | 1.5 | D.expinf | 1.2 | D.Fed | 1.47 |
| | D.Fed | 1.14 | D.Flow | 1.3 | D.Vobaa | 1.2 | D.Vobaa | 1.46 |
| | D.Flow | 1.06 | D.Fed | 1.3 | D.Fed | 1.1 | D.Expgr | 1.24 |
| | D.Expinf | 1.03 | D.Expinf | 1.1 | D.Expgr | 1 | D.Expinf | 1.22 |
| BAA | D.Vobaa | 1.02 | D.Vobaa | 1 | D.Flow | 1 | D.Flow | 1.08 |
| | D.Fed | 1.18 | D.Expgr | 1.5 | D.Expinf | 1.1 | D.Fed | 1.28 |
| | D.Expgr | 1.17 | D.Fed | 1.4 | D.Fed | 1.1 | D.Expinf | 1.21 |
| | D.Flow | 1.06 | D.Flow | 1.3 | D.Voltenyr | 1.1 | D.Expgr | 1.11 |
| | D.Voltenyr | 1.06 | D.Voltenyr | 1.1 | D.Expgr | 1 | D.Voltenyr | 1.07 |
| TENYR | D.Expinf | 1.03 | D.Expinf | 1.1 | D.Flow | 1 | D.Flow | 1.02 |
| | D.Expgr | 1.17 | D.Expgr | 1.5 | D.Expinf | 1.2 | D.Fed | 1.29 |
| | D.Fed | 1.15 | D.Fed | 1.3 | D.Fed | 1.1 | D.Expinf | 1.26 |
| | D.Flow | 1.06 | D.Flow | 1.3 | D.Volmrtg | 1.1 | D.Expgr | 1.25 |
| | D.Expinf | 1.04 | D.Expinf | 1.1 | D.Flow | 1 | D.Volmrtg | 1.25 |
| MRTG | D.Volmrtg | 1.03 | D.Volmrtg | 1.1 | D.Expgr | 1 | D.Flow | 1.03 |
| Variance Inflation Index above ten would indicate a serious multicollinearity problem. | | | | | | | | |

## Appendix A.VI: OLS Regression Results

Table A.13: OLS Regression Results for AAA Corporate Bond Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | coef | se | coef | se | coef | se | coef | se |
| Fed | 0.344*** | 0.079 | 0.480 | 0.313 | 0.268*** | 0.090 | -0.168 | 0.196 |
| Expinf | 0.793*** | 0.187 | 0.682 | 0.453 | 1.041*** | 0.256 | 2.485*** | 0.763 |
| Expgr | 0.239 | 0.182 | 0.176 | 0.430 | 0.494*** | 0.123 | -0.074 | 0.526 |
| Flow | -0.310*** | 0.116 | 0.140 | 0.353 | 0.092 | 0.199 | -0.053 | 0.056 |
| Volaaa | 0.281 | 0.379 | -0.102 | 0.849 | 0.390 | 0.886 | -1.449 | 1.410 |
| Constant | 3.019*** | 0.844 | 2.670 | 1.774 | 1.215 | 1.281 | 1.416 | 1.895 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

Table A.14: OLS Regression Results for BAA Corporate Bond Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | coef | se | coef | se | coef | se | coef | se |
| Fed | 0.351*** | 0.087 | 0.425 | 0.322 | 0.259** | 0.105 | -0.244 | 0.194 |
| Expinf | 0.928*** | 0.192 | 0.907** | 0.442 | 1.063*** | 0.248 | 2.749*** | 0.839 |
| Expgr | 0.351* | 0.207 | 0.034 | 0.485 | 0.599*** | 0.147 | -0.246 | 0.625 |
| Flow | -0.285** | 0.114 | 0.156 | 0.403 | 0.072 | 0.203 | -0.037 | 0.055 |
| Vobaa | 0.366 | 0.339 | 0.174 | 0.731 | -0.171 | 0.880 | -1.551* | 0.840 |
| Constant | 3.061*** | 0.916 | 3.379* | 1.825 | 1.930 | 1.270 | 2.565 | 3.036 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

Table A.15: OLS Regression Results for TEN Year Treasury Bond Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | coef | se | coef | se | coef | se | coef | se |
| Fed | 0.364** | 0.089 | 0.880** | 0.312 | 0.329** | 0.111 | 0.078 | 0.205 |
| Expinf | 1.054** | 0.215 | 0.308 | 0.503 | 1.418** | 0.323 | 0.446 | 1.091 |
| Expgr | -0.055 | 0.167 | 0.189 | 0.472 | 0.180 | 0.181 | -0.381 | 0.783 |
| Flow | -0.146 | 0.114 | 0.004 | 0.414 | 0.138 | 0.244 | -0.027 | 0.045 |
| Voltenyr | 0.064 | 0.376 | 0.496 | 0.879 | 0.136 | 0.847 | 0.275 | 1.123 |
| Constant | 1.555 | 0.981 | -0.151 | 1.879 | -0.598 | 1.916 | 4.454* | 2.285 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

Table A.16: OLS Regression Results for the MORTAGE Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | coef | se | coef | se | coef | se | coef | se |
| Fed | 0.441*** | 0.074 | 0.606** | 0.239 | 0.362*** | 0.100 | 0.186 | 0.138 |
| Expinf | 0.884*** | 0.201 | 0.547 | 0.345 | 0.992*** | 0.248 | 0.464 | 0.634 |
| Expgr | 0.186 | 0.183 | 0.177 | 0.400 | 0.451*** | 0.164 | -0.053 | 0.546 |
| Flow | -0.202* | 0.104 | 0.048 | 0.327 | 0.043 | 0.220 | -0.110*** | 0.041 |
| Volmrtg | 0.331 | 0.389 | 0.316 | 0.639 | 0.220 | 0.792 | 1.238* | 0.697 |
| Constant | 2.651*** | 0.942 | 2.992** | 1.273 | 1.511 | 1.200 | 4.584*** | 1.771 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

## Appendix A.VII: Regression Results with Differences

Table A.17: OLS Regression Results for AAA Corporate Bond Rate (Differences)

| | Whole period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | coef | se | coef | se | coef | se | coef | Se |
| D.Fed | 0.280*** | 0.061 | 0.375*** | 0.079 | 0.315** | 0.145 | 0.034 | 0.299 |
| D.Expinf | -0.068 | 0.324 | -0.077 | 0.311 | -0.189 | 0.866 | 0.520 | 1.421 |
| D.Expgr | 0.102 | 0.086 | 0.090 | 0.133 | 0.040 | 0.161 | 0.470 | 0.483 |
| D.Flow | -0.042 | 0.033 | 0.045 | 0.134 | -0.027 | 0.079 | -0.071** | 0.032 |
| D.Volaaa | -1.157*** | 0.422 | -1.014* | 0.545 | -1.661** | 0.818 | -1.101 | 1.838 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

Table A.18: OLS Regression Results for BAA Corporate Bond Rate (Differences)

| | Whole period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | Coef | se | coef | se | coef | se | coef | se |
| D.Fed | 0.287*** | 0.089 | 0.448*** | 0.117 | 0.268* | 0.147 | -0.054 | 0.283 |
| D.Expinf | 0.248 | 0.347 | 0.225 | 0.333 | 0.218 | 0.922 | 1.180 | 1.307 |
| D.Expgr | 0.037 | 0.089 | 0.029 | 0.134 | 0.085 | 0.177 | 0.267 | 0.441 |
| D.Flow | -0.041 | 0.036 | 0.036 | 0.132 | -0.040 | 0.071 | -0.069* | 0.042 |
| D.Vobaa | -0.988** | 0.475 | -0.882 | 0.551 | -1.316* | 0.759 | -1.027 | 1.393 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

Table A.19: OLS Regression Results for TEN Year Treasury Bond Rate (Differences)

| | Whole period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | Coef | se | coef | se | coef | se | coef | se |
| D.Fed | 0.373*** | 0.095 | 0.562*** | 0.099 | 0.376* | 0.204 | 0.072 | 0.264 |
| D.Expinf | -0.306 | 0.438 | -0.402 | 0.381 | 0.023 | 0.959 | -0.130 | 1.631 |
| D.expgr | 0.024 | 0.101 | 0.048 | 0.135 | -0.068 | 0.226 | 0.215 | 0.644 |
| D.flow | -0.027 | 0.044 | 0.058 | 0.183 | -0.002 | 0.098 | -0.057 | 0.044 |
| D.voltenyr | -1.006** | 0.511 | -0.794 | 0.657 | -1.861*** | 0.721 | -0.183 | 1.090 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

Table A.20: OLS Regression Results for MORTGAGE Rate (Differences)

| | Whole period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | coef | se | coef | se | coef | se | coef | se |
| D.Fed | 0.416*** | 0.089 | 0.600*** | 0.106 | 0.436** | 0.194 | 0.156 | 0.198 |
| D.Expinf | 0.263 | 0.269 | 0.315 | 0.289 | -0.106 | 1.022 | -0.041 | 1.214 |
| D.expgr | 0.059 | 0.111 | 0.070 | 0.142 | -0.001 | 0.239 | 0.323 | 0.465 |
| D.Flow | -0.071** | 0.035 | 0.048 | 0.134 | -0.087 | 0.095 | -0.104*** | 0.026 |
| D.Volmrtg | -0.631** | 0.311 | -0.634* | 0.339 | -0.939 | 0.730 | 0.712 | 0.883 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| NOTES: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level. | | | | | | | | |

## Appendix A.VIII: GMM Techniques and GMM Estimates

Another important problem in econometrics is the endogeneity of some of the variables in the regression equations. If the dependent variable and some of the regressors in the regression equation are simultaneously determined, endogeneity problems take place. As a result, the error term and regressors are not orthogonal to each other, which in turn produce biased estimates. Formally, if the regression equation is$= \sum_i^k \beta_i \ X_{i,t} + u_t$, endogeneity implies that $Cov(u_t | x_{1,t}, x_{2,t}, \ldots. x_{k,t}) \neq 0$ .

In our regression specification interest rates and foreign capital flows may be simultaneously determined. In other words, high interest rates may attract high capital flows and high capital flows may decrease interest rates, which means that we may face endogeneity problem. IV or GMM techniques can be used to address this problem. I will use GMM robust estimation technique for this part. GMM estimates are consistent and efficient estimates even in the presence of non i.i.d errors. The conventional IV and its variant 2SLS techniques can be considered as special cases of the GMM.

The GMM estimates can be derived as follows: Let the linear regression equation be $y = X\beta + u$ , where X is T*K matrix, $\beta$ is 1*K matrix $u$ is T*K matrix, and suppose that some regressors represented by $X_1$ (T*L matrix) are endogenous and instruments of these variables are represented by $Z$ (T*M matrix), where M$\geq L$,[12] then the moment condition can be written $E(Z'u) = 0$ which is equivalent to $f_M(\beta) = \ Z'_M \ u_M =$ $Z'_M \ (y_M \ - X_M \, \beta_M)$ . So, there are M moment conditions. If the number of unknowns are equal to the number of instruments (M=K), the moment conditions can be solved for unique estimates which are identical to conventional IV estimators. When there are more instruments than endogenous variables, there is no unique solution. In the IV case, this problem is overcome by combining the instruments in the first stage regression. In the GMM case, the solution to this problem is to choose such coefficients ($\hat{\beta}_{GMM}$) that make the moment function as close as possible to 0. In other words,$f_M\left(\hat{\beta}_{GMM}\right)' f_M(\hat{\beta}_{GMM})$ should be minimized.

[12] Exogenous variables can be considered their own instruments.

One major issue concerning IV or GMM is finding relevant instruments. The valid instruments must have high correlation with the variable(s) considered endogenous and must be orthogonal to the errors of the original regression. The tests related to these problems are explained in the text and in the notes below the GMM regression results tables.

Table A.21: GMM Regression Results for AAA Corporate Bond Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | coef | se | coef | se | coef | se | coef | se |
| Flow | -0.108 | 0.119 | 0.034 | 0.286 | 0.099 | 0.196 | -0.024 | 0.066 |
| Fed | 0.313*** | 0.076 | 0.494* | 0.273 | 0.267*** | 0.085 | -0.257* | 0.150 |
| Expinf | 0.971*** | 0.189 | 0.619* | 0.375 | 1.047*** | 0.246 | 2.648*** | 0.569 |
| Expgr | 0.151 | 0.191 | 0.240 | 0.329 | 0.492*** | 0.108 | -0.362 | 0.439 |
| Volaaa | 0.226 | 0.373 | -0.095 | 0.721 | 0.392 | 0.812 | -1.622 | 1.078 |
| Constant | 2.532*** | 0.804 | 2.788* | 1.687 | 1.194 | 1.212 | 2.228 | 1.517 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| Autocorrelation | 0.002 | | 0.035 | | 0.023 | | 0.123 | |
| Under-identification | 0.0035 | | 0.1065 | | 0.0648 | | 0.02 | |
| Redundancy | 0.0012 | | 0.0319 | | 0.0365 | | 0.0541 | |
| Weak identification | 60.241 | | 31.833 | | 38.524 | | 24.583 | |
| Orthogonality | 0.0507 | | 0.8272 | | 0.9573 | | 0.2559 | |
| Endogeneity | 0.5679 | | 0.7836 | | 0.9089 | | 0.5454 | |

**NOTES**: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level; **Autocorrelation Test**: Cumby-Huizinga test with null hypothesis that errors not auto correlated at order 1; **Under Identification Test** : The Kleibergen-Paap rk LM statistic is with the null hypothesis that the specified endogenous regressor is under identified by the specified instruments; **Redundancy Test**: IV redundancy test (LM test of redundancy of specified instruments) with the null hypothesis is that the specified instrument is redundant; **Weak Identification Test:** Kleibergen-Paap rk Wald F statistic with the null hypothesis is that instrument(s) are weakly correlated with the specified endogenous variable(s); **Orthogonality Test:** Hansen J statistic with the null hypothesis that the specified instruments are not correlated with error terms. **Endogeneity Test**: The Null Hypothesis is the specified regressor is endogenous. P values are reported for autocorrelation, under identification, redundancy, orthogonality and endogeneity tests. F Wald Statistics are reported for weak identification test.

Table A.22: GMM Regression Results for BAA Corporate Bond Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | Coef | se | coef | se | coef | se | coef | se |
| Flow | -0.078 | 0.121 | 0.074 | 0.326 | 0.182 | 0.205 | 0.002 | 0.086 |
| Fed | 0.325*** | 0.084 | 0.434 | 0.284 | 0.247** | 0.098 | -0.336** | 0.170 |
| Expinf | 1.110*** | 0.204 | 0.861** | 0.368 | 1.158*** | 0.243 | 2.687*** | 0.552 |
| Expgr | 0.232 | 0.217 | 0.076 | 0.373 | 0.591*** | 0.130 | -0.473 | 0.574 |
| Vobaa | 0.370 | 0.336 | 0.183 | 0.638 | -0.181 | 0.814 | -1.812*** | 0.701 |
| Constant | 2.561*** | 0.883 | 3.497** | 1.685 | 1.557 | 1.263 | 3.685 | 2.333 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| Autocorrelation | 0.007 | | 0.035 | | 0.028 | | 0.072 | |
| Under-identification | 0.003 | | 0.117 | | 0.072 | | 0.017 | |
| Redundancy | 0.0012 | | 0.0355 | | 0.037 | | 0.0287 | |
| Weak identification | 59.164 | | 27.04 | | 40.258 | | 13.98 | |
| Orthogonality | 0.133 | | 0.908 | | 0.830 | | 0.124 | |
| Endogeneity | 0.313 | | 0.818 | | 0.337 | | 0.798 | |

**NOTES**: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level; **Autocorrelation Test**: Cumby-Huizinga test with null hypothesis that errors not auto correlated at order 1; **Under Identification Test** : The Kleibergen-Paap rk LM statistic is with the null hypothesis that the specified endogenous regressor is under identified by the specified instruments; **Redundancy Test**: IV redundancy test (LM test of redundancy of specified instruments) with the null hypothesis is that the specified instrument is redundant; **Weak Identification Test:** Kleibergen-Paap rk Wald F statistic with the null hypothesis is that instrument(s) are weakly correlated with the specified endogenous variable(s); **Orthogonality Test:** Hansen J statistic with the null hypothesis that the specified instruments are not correlated with error terms. **Endogeneity Test**: The Null Hypothesis is the specified regressor is endogenous. P values are reported for autocorrelation, under identification, redundancy, orthogonality and endogeneity tests. F Wald Statistics are reported for weak identification test.

Table A.23: GMM Regression Results for TEN YEAR Treasury Bond Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | Coef | se | coef | se | coef | se | coef | se |
| Flow | 0.013 | 0.093 | 0.191 | 0.297 | 0.078 | 0.197 | -0.055 | 0.082 |
| Fed | 0.321*** | 0.077 | 0.845*** | 0.270 | 0.339*** | 0.105 | 0.102 | 0.210 |
| Expinf | 1.218*** | 0.179 | 0.419 | 0.412 | 1.370*** | 0.248 | 0.357 | 1.176 |
| Expgr | -0.109 | 0.177 | 0.075 | 0.362 | 0.164 | 0.162 | -0.358 | 0.725 |
| Volatenyr | 0.074 | 0.359 | 0.473 | 0.751 | 0.196 | 0.750 | 0.430 | 1.285 |
| Constant | 1.100 | 0.891 | -0.265 | 1.734 | -0.385 | 1.546 | 4.538* | 2.533 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| Autocorrelation | 0.016 | | 0.034 | | 0.039 | | 0.194 | |
| Under-identification | 0.004 | | 0.109 | | 0.0659 | | 0.011 | |
| redundancy | 0.0013 | | 0.033 | | 0.0375 | | 0.0278 | |
| Weak identification | 62.776 | | 31.137 | | 38.011 | | 16.226 | |
| Orthogonality | 0.343 | | 0.702 | | 0.731 | | 0.053 | |
| Endogeneity | 0.312 | | 0.695 | | 0.899 | | 0.696 | |

**NOTES**: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level; **Autocorrelation Test**: Cumby-Huizinga test with null hypothesis that errors not auto correlated at order 1; **Under Identification Test** : The Kleibergen-Paap rk LM statistic is with the null hypothesis that the specified endogenous regressor is under identified by the specified instruments; **Redundancy Test**: IV redundancy test (LM test of redundancy of specified instruments) with the null hypothesis is that the specified instrument is redundant; **Weak Identification Test:** Kleibergen-Paap rk Wald F statistic with the null hypothesis is that instrument(s) are weakly correlated with the specified endogenous variable(s); **Orthogonality Test:** Hansen J statistic with the null hypothesis that the specified instruments are not correlated with error terms. **Endogeneity Test**: The Null Hypothesis is the specified regressor is endogenous. P values are reported for autocorrelation, under identification, redundancy, orthogonality and endogeneity tests. F Wald Statistics are reported for weak identification test.

Table A.24: GMM Regression Results for MORTGAGE Rate

| | Whole Period | | Period 1 | | Period 2 | | Period 3 | |
|---|---|---|---|---|---|---|---|---|
| | Coef | se | coef | se | coef | se | coef | se |
| Flow | -0.010 | 0.092 | 0.133 | 0.262 | 0.102 | 0.223 | -0.134** | 0.068 |
| Fed | 0.396*** | 0.068 | 0.594*** | 0.217 | 0.354*** | 0.096 | 0.203 | 0.151 |
| Expinf | 1.078*** | 0.190 | 0.604* | 0.328 | 1.045*** | 0.248 | 0.270 | 0.687 |
| Expgr | 0.100 | 0.189 | 0.168 | 0.336 | 0.450*** | 0.143 | -0.020 | 0.589 |
| Volmrtg | 0.289 | 0.380 | 0.250 | 0.572 | 0.213 | 0.721 | 1.241* | 0.658 |
| Cons | 2.172** | 0.893 | 2.821** | 1.139 | 1.300 | 1.166 | 4.933** | 2.023 |
| # of obs. | 99 | | 30 | | 39 | | 23 | |
| Autocorrelation | 0.013 | | 0.039 | | 0.037 | | 0.092 | |
| Under-identification | 0.004 | | 0.108 | | 0.0673 | | 0.008 | |
| redundancy | 0.0012 | | 0.033 | | 0.037 | | 0.0311 | |
| Weak identification | 63.668 | | 31.094 | | 40.927 | | 20.374 | |
| Orthogonality | 0.328 | | 0.841 | | 0.986 | | 0.460 | |
| Endogeneity | 0.161 | | 0.618 | | 0.641 | | 0.536 | |

**NOTES**: *** Indicates 1% significance level; **Indicates 5 % significance level; * Indicates 10 % significance level; **Autocorrelation Test**: Cumby-Huizinga test with null hypothesis that errors not auto correlated at order 1; **Under Identification Test** : The Kleibergen-Paap rk LM statistic is with the null hypothesis that the specified endogenous regressor is under identified by the specified instruments; **Redundancy Test**: IV redundancy test (LM test of redundancy of specified instruments) with the null hypothesis is that the specified instrument is redundant; **Weak Identification Test:** Kleibergen-Paap rk Wald F statistic with the null hypothesis is that instrument(s) are weakly correlated with the specified endogenous variable(s); **Orthogonality Test:** Hansen J statistic with the null hypothesis that the specified instruments are not correlated with error terms. **Endogeneity Test**: The Null Hypothesis is the specified regressor is endogenous. P values are reported for autocorrelation, under identification, redundancy, orthogonality and endogeneity tests. F Wald Statistics are reported for weak identification test.