
Interest rate pass through and asymmetric adjustment: evidence from the federal funds rate operating target period

James E. Payne* and George A. Waters

*Department of Economics, Illinois State University, Normal,
IL 61790-4200, USA*

This study examines the long-run interest rate pass through of the federal funds rate to the prime rate and whether there is asymmetric adjustment in the prime rate using the Enders–Siklos (2001) momentum threshold autoregressive model over the period February 1987 to October 2005. Once allowance is made for the endogenously determined structural break in the cointegrating relationship in April 1996, the adjustment of the prime rate to changes in the federal funds rate appears asymmetric with upward rigidity, a result contrary to previous studies which found that the prime rate exhibits downward rigidity. The finding of upward rigidity in the prime rate lends support for the customer reaction and adverse selection hypotheses. Moreover, the empirical evidence seems to support the observation of increased pass through as a result of heightened competition in the banking industry as well as the Federal Reserve's enhanced transparency in monetary policy during the 1990s.

I. Introduction

The transmission of monetary policy in the United States to the real sector hinges in part on the degree to which banks change lending rates in response to changes in the banks' cost of funds as represented by the federal funds rate. If monetary policy actions are to be effective, changes in the federal funds rate should be completely 'passed through' to lending rates within a relatively short time horizon. However, it is often the case that changes in the federal funds rate are not completely passed through to lending rates (i.e. interest rate rigidity). As discussed

by Stiglitz and Weiss (1981), interest rate rigidity can be attributed to adjustment costs and information asymmetries in credit markets. Such adjustment costs may stem from the search for information; the menu costs of adjusting rates; the costs associated with adverse selection and moral hazard; as well as consumer inertia and switching costs. In addition to the presence of adjustment costs, an added dimension to the transmission of monetary policy has been the substantial changes in the US financial system since the early 1980s and throughout the 1990s as a result of deregulation of the US banking system, the evolution of financial innovations, and greater monetary

*Corresponding author. E-mail: jepayne@ilstu.edu

policy transparency. These changes may have influenced the responsiveness of lending rates to changes in the federal funds rate.¹

This study examines the extent of interest rate pass through from the federal funds rate to the prime rate along with the asymmetric adjustment of the prime rate in response to changes in the federal funds rate during period in which the Federal Reserve began using the federal funds rate as an operating target. The prime rate is used given that most lending rates are tied to some degree to the prime rate. Though the prime rate may no longer be viewed as the rate charged to the most creditworthy customers, the prime rate still serves as a base rate in a bank's loan rate structure, including credit card and automobile loans as well as reflect the changes in a bank's cost of funds (Mester and Saunders, 1995; Dueker, 2000). The analysis will attempt to answer several questions: (1) Is there complete interest rate pass through from the federal funds rate to the prime rate?² (2) Did a structural break occur in the relationship between the prime rate and the federal funds rate and if so did it alter the degree of interest rate pass through? and (3) Does the prime rate adjust asymmetrically to changes in the federal funds rate and if so is there upward or downward rigidity? Section II provides an overview of the various explanations for asymmetric interest rate adjustments. Section III describes the data, methodology, and empirical results while concluding remarks are given in Section IV.

II. Explanations for Interest Rate Adjustments

The issue of interest rate pass-through and interest rate rigidities have been explored by a number of

researchers in the United States (Hadjimichalakis, 1981; Arak *et al.*, 1983; Slovin and Suska, 1983; Goldberger 1984; Cook and Hahn, 1989; Hannan and Berger, 1991; Neumark and Sharpe, 1992; Diebold and Sharpe, 1990; Mester and Saunders, 1995; Moazzami, 1999; Scholnick, 1999; Dueker, 2000; Tkacz, 2001; Sarno and Thornton, 2003; Payne, 2006). Of the studies cited only a few have dealt explicitly with the issue of interest rate pass through and rigidity with respect to the prime rate.³ While Goldberger (1984) did not find support for asymmetry in the adjustment of the prime rate in response to changes in market rates, the majority of the studies indicate that the prime rate exhibits downward rigidity. Specifically, Hadjimichalakis (1981), Arak *et al.* (1983), Forbes and Mayne (1989), Levine and Loeb (1989), Mester and Saunders (1995), Dueker (2000) and Thacz (2001) present evidence to suggest that the prime rate exhibits downward rigidity with respect to declining money market rates. Indeed, if lending rates are rigid downward, restrictive monetary policy will have more of an impact than expansionary monetary policy as lending rates adjust rapidly to rising market rates, but are slow to adjust in response to falling market rates. Moreover, the slow adjustment of the prime rate may make bank-dependent firms more vulnerable to business cycle fluctuations than firms with direct access to capital markets.

There have been several explanations set forth to explain the extent of interest rate pass through and the adjustment of lending rates to changes in the federal funds rate.⁴ The collusive pricing hypothesis, or sometimes called the bank concentration hypothesis, states that banks are less likely to decrease lending rates in fear of disrupting collusive arrangements, in turn, resulting in the downward rigidity of lending rates.⁵ The consumer behavior hypothesis

¹ Sellon (2002) makes this point and provides a nice overview of the impact of the changing US financial system on the interest rate channel for monetary policy transmission.

² The issue of interest rate pass through along with the adjustment process has been undertaken for a number of countries, for example, Singapore and Malaysia by Scholnick (1996); United Kingdom by Heffernan (1997) as well as Hofmann and Mizen (2004); Germany by Winker (1999); and Australia by Lim (2001). Frost and Bowden (1999) examine an asymmetric error correction model in the adjustment of mortgage rates in New Zealand.

³ Cook and Hahn (1989) analyse US Treasury securities. Diebold and Sharpe (1990), Hannan and Berger (1991), Neumark and Sharpe (1992) and Hutchison (1995) examine various deposit rates. Scholnick (1999) and Payne (2006) investigate mortgage rates while Moazzami (1999) as well as Sarno and Thornton (2003) focus on the 3-month US Treasury bill rate. Atesoglu (2004) analyses long-term rates. More specifically to this study, Atesoglu (2003) finds an increase in interest rate pass through from the federal funds rate to the prime rate in the post-1994 period. However, Atesoglu (2003) does not endogenously determine a structural break in the relationship between the federal funds rate and the prime rate as well as incorporate the possibility of asymmetric adjustment.

⁴ Scholnick (1999) provides a survey of the various explanations for interest rate rigidity and the adjustment processes of lending and deposit rates.

⁵ Berger and Hannan (1989) find that banks in more concentrated markets pay less in terms of deposit rates. Hannan and Berger (1991) as well as Neumark and Sharpe (1992) discuss the collusive pricing and customer reaction hypotheses. In a related literature, Ewing *et al.* (1998), Ewing and Kruse (2005) and Thompson (2006) examine the relationship between the prime rate and CD rates.

focuses on the degree of consumer sophistication with respect to financial markets as well as the potential search and switching costs associated with alternative suppliers of financial services and products. The greater the proportion of unsophisticated consumers relative to sophisticated consumers along with the search and switching costs enables banks to have greater market power in the adjustment of interest rates to their advantage. As in the case of the collusive hypothesis, the consumer behavior hypothesis suggests that lending rates are rigid downward.

However, the asymmetric adjustment in lending rates may actually benefit the consumer. The customer reaction hypothesis suggests that banks, especially operating in a highly competitive environment, may fear a negative reaction from customers in response to lending rate increases. Thus, the customer reaction hypothesis supports the asymmetric adjustment of interest rates with lending rates rigid upward. The presence of asymmetric information may create an adverse selection problem in lending markets in that higher interest rates will tend to attract riskier borrowers (Stiglitz and Weiss, 1981). In response, banks will not increase lending rates, but instead ration credit in an attempt to avoid the costs associated with the loan defaults of riskier borrowers. Thus, the adverse selection hypothesis is supported if lending rates are rigid upward.

The next section will describe the data and methodology in analysing the issue of interest rate pass through and asymmetric adjustments in the prime rate in response to changes in the federal funds rate along with empirical results.

III. The Data, Methodology and Results

Monthly data from February 1987 to October 2005 on the prime interest rate (P) and the federal funds rate (FFR) were obtained from the St. Louis Federal Reserve Bank database, FRED II. As evident from Fig. 1, the prime rate and federal funds rate appear to move together. To gain further insight into the observed co-movement between the prime rate and the federal funds rate, unit root and bivariate cointegration analysis are undertaken. Panel A of Table 1 reports the augmented Dickey–Fuller

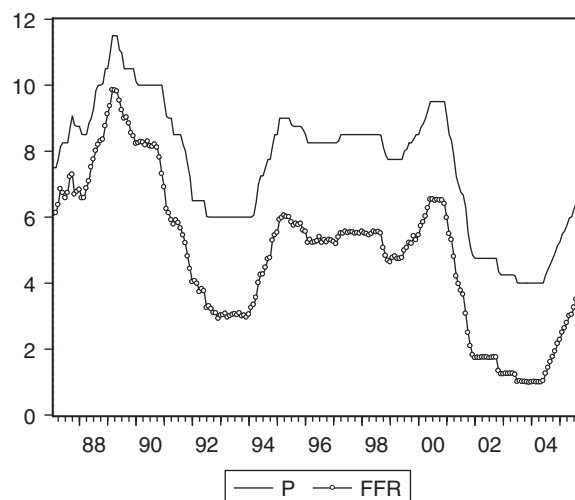


Fig. 1. Prime rate and federal funds rate (February 1987 to October 2005)

(ADF, 1979), Phillips–Perron (PP, 1988), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS, 1992) unit root tests. The ADF and PP unit roots are based on the null hypothesis that the respective time series are difference stationary while the KPSS unit root test is based on the null hypothesis of trend stationarity. The ADF, PP, and KPSS unit root tests reveal that the respective interest rates are integrated of order one with two exceptions. The ADF (C+T) unit root test suggests that the prime rate is stationary in levels while the KPSS (C+T) unit root test indicates the federal funds rate is also stationary in levels as well. Given the slow decay in the autocorrelation function for each time series, the analysis proceeds with both the prime rate and federal funds exhibiting unit root behavior and first-difference stationary.⁶

The degree of interest rate pass through in the long run between the prime rate and the federal funds rate is examined by estimating the following bivariate relationship (Freixas and Rochet, 1997):

$$P_t = \alpha_p + \beta_p FFR_t + \varepsilon_t \quad (1)$$

where the intercept term, α_p , may be considered a constant loan intermediation margin and the slope coefficient, β_p , measures the degree of interest rate pass through in the long run from the federal funds rate to the prime rate. Complete pass through exists in the long run if $\beta_p = 1$. If $\beta_p < 1$, there is incomplete

⁶Perron's (1997, pp. 358–359) endogenous unit root test was performed on the prime rate and federal funds rate. The break date selected was based on the minimum ADF test statistic for testing the null hypothesis of a unit root. Though each series exhibited a break (prime rate July 1996 and federal funds rate September 1995), both series still contained a unit root (i.e. integrated of order one). The test statistics associated with the null hypothesis of a unit root were -4.04 for the prime rate and -3.72 for the federal funds rate, both less than the 10% critical value of -4.82 (Perron, 1997, Table 1, p. 362).

Table 1. Unit root and cointegration tests February 1987 to October 2005

Variable	ADF(C)	ADF(C+T)	PP(C)	PP(C+T)	KPSS(C)	KPSS(C+T)
Panel A: Unit root tests						
P_t	-1.93	-3.45 ^c	-1.57	-2.22	0.838 ^a	0.136 ^c
ΔP_t	-4.94 ^a	-	-8.82 ^a	-8.81 ^a	0.091	0.083
FFR_t	-1.79	-2.89	-1.49	-2.03	1.027 ^a	0.118
ΔFFR_t	-3.71 ^a	-3.70 ^a	-8.92 ^a	-8.90 ^a	0.075	-
Panel B: Engle–Granger cointegration test						
$P_t = 3.48 + 0.841FFR_t$ (0.096) ^a (0.023) ^a	$\beta_p = 1$ -6.91 ^a	ADF -2.78	k 4			
Panel C: Gregory–Hansen cointegration test/DOLS estimates						
$P_t = 1.27 + 1.38D + 1.06FFR_t$ (0.122) ^a (0.061) ^a (0.014) ^a		Break April 1996	ADF* -5.34 ^a			

Notes: Critical values for the ADF(C) and PP(C) unit root tests which include only a constant: ^a(1%) -3.46, ^b(5%) -2.87 and ^c(10%) -2.57. Critical value for the KPSS(C) unit root test which includes only a constant: ^a(1%) 0.739, ^b(5%) 0.463 and ^c(10%) 0.347. Critical values for ADF(C+T) and PP(C+T) unit root tests which include both a constant and trend: ^a(1%) -4.00, ^b(5%) -3.43 and ^c(10%) -3.14. Critical values for KPSS(C+T) unit root test which includes both a constant and trend: ^a(1%) 0.216, ^b(5%) 0.146 and ^c(10%) 0.119. Newey–West heteroscedasticity consistent standard errors are reported in parentheses with a 1% significance level denoted by 'a'. Engle–Granger (1987) ADF critical values for cointegration test: ^a(1%) -3.93, ^b(5%) -3.17 and ^c(10%) -2.91. $\beta_p = 1$ is the null hypothesis of complete pass through in the long-run. The t -statistic of -6.91 rejects the null hypothesis of complete pass through in the long run. k denotes the number of auxiliary regressors in the ADF cointegration test. Standard errors are reported in parentheses with a 1% significance level denoted by 'a'. Break date is April 1996. Gregory–Hansen (1996) ADF* critical values for regime shift cointegration test: ^a(1%) -5.13, ^b(5%) -4.61 and ^c(10%) -4.34.

pass-through in the long run perhaps attributable to switching costs, informational asymmetries, or other market imperfections. On the other hand, if $\beta_p > 1$, banks are not rationing the credit supply, but increasing lending rates to compensate for additional risks (de Bondt, 2002). Panel B of Table 1 presents the results of estimating Equation 1 within the cointegration framework of Engle and Granger (1987). The intercept estimate, representing the loan intermediation margin, is 3.48% while the slope coefficient estimate, measuring the degrees of interest rate pass through, is 0.841. The slope coefficient is significantly less than one, indicative of incomplete pass through from the federal funds rate to the prime rate. However, the ADF unit root test of the residuals from the cointegrating equation is not significant at the 10% level.

As pointed out by Gregory and Hansen (1996), the power of the standard ADF cointegration tests of the residuals from a cointegrating regression decreases in the presence of a structural break. Gregory and Hansen (1996) propose a cointegration procedure that allows for an endogenously

determined break in the cointegrating relationship. Given the timing of the structural break is unknown a priori, Gregory and Hansen (1996) compute the cointegration test statistic, ADF*, for each possible break and take the minimum test statistic across all possible break points utilizing the following specification:

$$P_t = \alpha_p + \alpha_p^D D + \beta_p FFR_t + \varepsilon_t \quad (2)$$

where D_t is a dummy variable equal to 0.0 if $t \leq \theta$ and 1.0 if $t > \theta$; the unknown parameter θ denotes the timing of the change; and α_p^D denotes the change in the intercept coefficient at the time of the shift. The results of the Gregory–Hansen test are reported in Panel C of Table 1. The hypothesis of cointegration with a structural break is supported at better than 1% significance level, with the ADF* statistic of -5.34 and the break occurring in April 1996. The structural break date of April 1996 is within two years of when the prime rate was set at a fixed 3% premium over the federal funds rate and the passage of the Riegle–Neal Interstate Banking and Branching Efficiency Act of 1994 (Sellon, 2002).⁷ In order to deal with the issue

⁷ The Riegle–Neal Interstate Banking and Branching Efficiency Act eliminated the prohibition of interstate banking and permitted branching across state lines. In 1999, the Gramm–Leach–Bliley Financial Services Modernization Act permitted security firms and insurance companies to purchase banks as well as enabled banks to underwrite securities, insurance and real estate.

of statistical inference in a cointegrated system with structural changes, the method of dynamic ordinary least squares (DOLS) advanced by Stock and Watson (1993) is used to estimate Equation 2 as shown in Panel C of Table 1.⁸ In light of the structural break, the degree of interest rate pass through increased. The slope coefficient is significantly greater than one, suggesting that perhaps banks tend to increase lending rates to compensate for additional risks as pointed out by de Bondt (2002).

Taking into account the structural break in the cointegrating relationship between the prime rate and the federal funds rate, the adjustment of the prime rate to changes in the federal funds rate in the long run is explored allowing for the possibility of asymmetries in the error correction process. The momentum threshold autoregressive (MTAR) model of Enders and Siklos (2001) is utilized.⁹ As discussed by Enders and Siklos (2001), the distinction with respect to asymmetries is important given that standard cointegration tests have low power in the presence of an asymmetric adjustment process. The MTAR model is especially valuable when the adjustment is believed to exhibit more momentum in one direction than the other.¹⁰ Specifically, the MTAR model uses the residuals generated from Equation 2, $\hat{\varepsilon}_t$, and estimates Equations 3 and 4.

$$\Delta \hat{\varepsilon}_t = I_t \rho_1 \hat{\varepsilon}_{t-1} + (1 - I_t) \rho_2 \hat{\varepsilon}_{t-1} + \sum_{i=1}^p \alpha_i \Delta \hat{\varepsilon}_{t-p} + \hat{u}_t \quad (3)$$

where $\hat{u}_t \sim I.I.D(0, \sigma^2)$ and the lagged values of $\Delta \hat{\varepsilon}_t$ yield uncorrelated residuals. The Heaviside indicator function is denoted as follows:

$$I_t = \begin{cases} 1 & \text{if } \Delta \hat{\varepsilon}_{t-1} \geq \tau \\ 0 & \text{if } \Delta \hat{\varepsilon}_{t-1} < \tau \end{cases} \quad (4)$$

where the threshold, τ , is endogenously determined using Chan's (1993) method.¹¹ Equations 2–4

represent an MTAR model in which the indicator variable depends on the previous period's change in $\Delta \hat{\varepsilon}_{t-1}$. If $\Delta \hat{\varepsilon}_{t-1}$ is above the threshold, the adjustment is captured by $\rho_1 \hat{\varepsilon}_{t-1}$, on the other hand, if $\Delta \hat{\varepsilon}_{t-1}$ is below the threshold, the adjustment is measured by $\rho_2 \hat{\varepsilon}_{t-1}$. For instance, $\Delta \hat{\varepsilon}_{t-1} < \tau$ is indicative of a rise in the federal funds rate relative to the prime rate, a narrowing of the spread between the prime rate and federal funds rate, initiating an upward adjustment in the prime rate. On the other hand, $\Delta \hat{\varepsilon}_{t-1} > \tau$ reflects a decrease in the federal funds rate relative to the prime rate, a widening of the spread between the prime rate and federal funds rate, inducing a downward adjustment in the prime rate.

Within the MTAR model, the null hypothesis of no cointegration can be tested by the restriction, $\rho_1 = \rho_2 = 0$, while the null hypothesis of symmetry can be tested by the restriction, $\rho_1 = \rho_2$. Panel A of Table 2 displays the results of the tests of cointegration, $\rho_1 = \rho_2 = 0$, and symmetry, $\rho_1 = \rho_2$. The estimates of ρ_1 and ρ_2 from the MTAR model satisfy the stationarity (convergence) conditions. Based on the $\Phi^*(M) = 13.79$ for $\rho_1 = \rho_2 = 0$, the null hypothesis of no cointegration is rejected at the 1% level. Given that the prime rate and federal funds rate are cointegrated, it is possible to test the null hypothesis of symmetric adjustment, $\rho_1 = \rho_2$. Based on the F -statistic = 3.66 for the null hypothesis, $\rho_1 = \rho_2$, the null hypothesis of symmetric adjustment is rejected at the 5% level. Given $|\rho_1| > |\rho_2|$, it appears that adjustment towards the long run equilibrium is faster for a decrease in the federal funds rate relative to the prime rate while the adjustment is slower for a rise in the federal funds rate relative to the prime rate. In other words, the speed of adjustment of the prime rate to an increase in the federal funds rate is slower than when the federal funds rate decreases.

Given the presence of cointegration between the prime rate and the federal funds rate as well as

⁸ DOLS is the dynamic ordinary least squares regression of P_t on a constant, D , FFR_t , ΔFFR_t , ΔFFR_{t-1} , ΔFFR_{t-2} , ΔFFR_{t+1} and ΔFFR_{t+2} . As pointed out by Stock and Watson (1993, p. 784), the DOLS estimator is asymptotically equivalent to the Johansen/Ahn-Reinsel estimator.

⁹ Bohl and Siklos (2004) use the MTAR model to examine the asymmetric behaviour exhibited by the Bundesbank's inflationary policy. In particular, it is possible to examine whether banks attempt to smooth out changes in market interest rates using the MTAR model. While Enders and Siklos (2001) examine the threshold autoregressive (TAR) model, the TAR model has lower power when compared to the standard Engle–Granger test. On the other hand, the MTAR model exhibits greater power than the Engle–Granger test.

¹⁰ As pointed out by Bohl and Siklos (2004, footnote 10, p. 508), the MTAR model captures the possibility of asymmetrically sharp adjustments toward the long-run equilibrium, in this case the long-run equilibrium between the prime rate and federal funds rate.

¹¹ The Chan (1993) method arranges the values $\Delta \hat{\varepsilon}_t$ for the MTAR in ascending order and excludes the smallest and largest 15%. The consistent estimate of the threshold is the parameter which yields the smallest residual sum of squares over the remaining 70%.

Table 2. Tests of cointegration/symmetry and asymmetric error correction model February 1987 to October 2005

Panel A: Tests of cointegration and symmetry: MTAR							
Prime rate:	Equations 2 and 3						
MTAR	τ	ρ_1	ρ_2	$\rho_1 = \rho_2 = 0$	$\rho_1 = \rho_2$	$Q(4)$	k
	0.106	-0.37 (-4.87) ^a	-0.20 (-2.89) ^a	13.79 ^a	3.66 [0.05] ^b	2.07 [0.72]	4
Panel B: Prime rate-federal funds rate asymmetric error correction model:							
Equation 5:	Independent variables						
	$\alpha_1 = \alpha_2 = 0$	$\gamma_1 = \gamma_2 = 0$	ρ_1	ρ_2	$Q(4)$	$F_{6,216}$	\bar{R}^2
ΔP_t	1.93 [0.15]	15.70 [0.00] ^a	-0.13 (-2.07) ^b	-0.10 (-1.89) ^c	3.14 [0.53]	40.30 [0.00] ^a	0.52
Equation 6:	Independent variables						
	$\tilde{\alpha}_1 = \tilde{\alpha}_2 = 0$	$\tilde{\gamma}_1 = \tilde{\gamma}_2 = 0$	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$Q(4)$	$F_{6,216}$	\bar{R}^2
ΔFFR_t	2.73 [0.07] ^c	12.10 [0.00] ^a	0.08 (0.84)	0.10 (1.14)	5.69 [0.22]	9.28 [0.00] ^a	0.18

Notes: τ represents threshold value. $\rho_1 = \rho_2 = 0$ denotes the null hypothesis of no cointegration with critical values obtained from Enders and Dibooglu (2001, p. 436, Table 1, $n = 250$ and four lagged changes, $\Phi^*(M)$: ^a(1%) 10.26, ^b(5%) 7.80 and ^c(10%) 6.66. $\rho_1 = \rho_2$ denotes the null hypothesis of symmetry in ρ_1 and ρ_2 . $Q(4)$ is the Box-Pierce Q -statistics for serial correlation up to 4 lags. k is the number of lags in the MTAR specification in Equation 3. t -statistics are in parentheses while probability values are in brackets. Partial F -statistics for lagged values of changes in the prime rate and federal funds rate, respectively, are reported under the specified null hypotheses. $Q(4)$ is the Box-Pierce Q -statistic to test for serial correlation up to 4 lags. $F_{6,216}$ is the overall F -statistic for the respective equations. t -statistics are reported in parentheses while probability values are reported in brackets. Significance levels are denoted as follows: ^a(1%), ^b(5%) and ^c(10%).

asymmetric adjustment within the MTAR model, an asymmetric error correction model is estimated to capture the short-run and long run dynamics.

$$\Delta P_t = \alpha_0 + \sum_{i=1}^n \alpha_i \Delta P_{t-i} + \sum_{i=1}^q \gamma_i \Delta FFR_{t-i} + I_t \rho_1 \hat{\varepsilon}_{t-1} + (1 - I_t) \rho_2 \hat{\varepsilon}_{t-1} + u_{1t} \quad (5)$$

$$\Delta FFR_t = \tilde{\alpha}_0 + \sum_{i=1}^n \tilde{\alpha}_i \Delta P_{t-i} + \sum_{i=1}^q \tilde{\gamma}_i \Delta FFR_{t-i} + I_t \tilde{\rho}_1 \hat{\varepsilon}_{t-1} + (1 - I_t) \tilde{\rho}_2 \hat{\varepsilon}_{t-1} + u_{2t} \quad (6)$$

where $u_{1,2t} \sim I.I.D(0, \sigma^2)$, and $\hat{\varepsilon}_{t-1} = P_{t-1} - \hat{\alpha}_P - \hat{\alpha}_P^D D - \hat{\beta}_P FFR_{t-1}$, and I_t takes the form given in (4). With respect to the prime rate and Equation 5, if the prime rate is above the threshold value following a decline in the federal funds rate, then the prime rate will adjust by ρ_1 . On the other hand, if the prime rate is below the threshold value following an increase in the federal funds rate, then the prime rate will adjust by ρ_2 . As a side note, the analysis thus far has assumed that the federal funds rate is exogenous to the prime rate. This assumption is supported if the asymmetric error correction terms in Equation 6 are each statistically insignificant.¹²

Panel B of Table 2 reports the results of the asymmetric error correction model. Equations 5

and 6 are absent of serial correlation and exhibit predictive power as evident from the Box-Pierce Q -statistic and overall F -statistic, respectively. The partial F -statistics indicate bi-directional Granger-causality between the prime rate and the federal funds rate in the short run. Moreover, given the statistical insignificance of the asymmetric error correction terms in Equation 6, the federal funds rate is considered weakly exogenous to the prime rate. The t -statistics for the error correction terms in Equation 5 indicate that the response of the prime rate, ρ_1 , to a decline in the federal funds rate is much larger (in absolute terms) than the response of the prime rate, ρ_2 , to a rise in the federal funds rate. This finding of upward rigidity lends support for the customer reaction and adverse selection hypotheses, contrary to the previous literature which suggests that the prime rate exhibits downward rigidity in response to a decline in the federal funds rate.

During this period there was not only a change in the Federal Reserve's operating procedures, but also further deregulation of the banking industry. The McFadden Act of 1927 and Glass-Steagall Act of 1933 were repealed with the passage of the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 and the Gramm-Leach-Bliley Financial Services Modernization Act of

¹² In this case, weak exogeneity occurs when changes in the federal funds rate do not react to the disequilibrium error terms but may still be influenced by lagged changes in the prime rate (Lim, 2001, p. 2001). For further discussion of the various forms of exogeneity see Engle *et al.* (1983).

1999, respectively. As a result the banking industry experienced substantial competition. In light of these events, it has been suggested by Sellon (2002) that in the post-deregulation period monetary policy became more transparent and the lags in monetary policy may have been shortened, not to mention that banks were operating in a highly competitive environment.¹³

IV. Concluding Remarks

This study attempts to answer several questions concerning the relationship between the prime rate and federal funds rate over the period February 1987 to October 2005 whereby the Federal Reserve pursued targeting the federal funds rates as its operating procedure. First, is there complete interest rate pass through from the federal funds rate to the prime rate? The initial evidence suggests there is incomplete pass through perhaps due to the presence of switching costs, informational asymmetries, or other market imperfections. Over the period February 1987 to October 2005, the pass through estimate is 0.841; however, after incorporating a structural break in April 1996 the pass through estimate increased to 1.06. Indeed, the empirical evidence seems to support Sellon's (2002) observation of increased pass through as a result of heightened competition in the banking industry and the Federal Reserve's enhanced transparency in monetary policy. Second, does the prime rate exhibit asymmetric adjustment to changes in the federal funds rate and is there upward or downward rigidity? There is evidence in support of asymmetric adjustment in the form of upward rigidity. The prime rate adjusts faster to a decrease in the federal funds rate relative to an increase in the federal funds rate. Such behavior lends support for the consumer reaction hypothesis of competitive banking markets as well as the adverse selection hypothesis in lending.

In summary, unlike the previous studies which found that the prime rate exhibits downward rigidity, the results indicate upward rigidity in the adjustment of the prime rate. In part, these results can be attributed to the greater transparency in monetary policy during the 1990s as well as the Federal Reserve's emphasis on targeting the federal funds rate.

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¹³The McFadden Act of 1927 prohibited banks from branching across state lines while the Glass-Steagall Act of 1933 separated commercial banking activities from the securities industry along with placing interest-rate ceilings on deposits.

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