

Monetary Transmission Mechanism: Empirical Evidence from Eurozone

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Abstract This paper examines the effectiveness and extent of monetary transmission mechanism from Federal Funds Rate (FFR) to London Interbank Offered Rate (LIBOR). The paper employs a co-integration technique, Granger causality test, and vector Error Correction (VEC) model to examine the direction of causality and the extent and size of the pass-through effect from FFR to LIBOR. The study considers two sub-periods: the first period spans 1994:02-2008:12, and the second period covers 2009:01-2019:01, recognized as a period of implementing unconventional monetary policy to find out if there is any difference between the size of the pass-through effect during the conventional and unconventional monetary policy. Finally, the study uses a structural VAR model to measure the impact of a shock to FFR on the Eurozone economic growth. The estimated results indicate a significant co-integration relationship between FFR and LIBOR for both sub-periods and the causality runs from FFR to LIBOR in both periods. However, the pass through effect is statistically stronger in the second sub-period during unconventional monetary policy. In addition, the results suggest that a shock to FFR has a significant impact on the level of economic growth in Eurozone. This result has important policy implications for monetary authorities in the Eurozone as they can offset the effects of a shock to FFR by using the appropriate monetary policy.

Keywords: Federal Funds Rate (FFR), London Interbank Offered Rate (LIBOR), pass-through effect, monetary policy transmission channel, Vector Error Correction (VEC) Model, Co-integration, Structural VAR

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1. Introduction

Understanding the transmission of monetary policy channel, especially at the international level, has important policy implications for macro-economies in different regions. Monetary policy affects the cross-border economies through a number of monetary transmission channels, including the interest rate. In recent years, the Federal Reserve has increasingly focused on the Federal Funds Rate (FFR) as the primary instrument of monetary policy. Thus, a large amount of literature has emerged examining the relationship between FFR and market interest rates.

This paper extends the research of Atesoglu [1,2], Payne [3], Nishiyama [4], Friedman & Shachmurove [5], and Buch, Bussiere, Goldberg, and Hills [6] by examining the relationship between FFR and the London Interbank Offered Rate (LIBOR), a benchmark rate that leading international banks, particularly in Eurozone area, charge each other for short-term loans [7].

The paper also examines the direction of causality and the extent of pass-through effect between FFR and LIBOR. The study compares the short and long-term effects of this relationship through Vector Error Correction model. One

of the novel features of this study is that it extends the data to capture the effects of pass-through effect from FFR to LIBOR during the period of liquidity trap, when Fed implemented unconventional monetary policy.

To separate the effects of pass-through effects under conventional and unconventional monetary policy, the study distinguishes between two sub-periods. The first sub-period spans 1990:01-2008:12 and the second sub-period covers 2009:01-2019:01, when unconventional monetary policy was implemented due to liquidity trap. These two sub-periods represent two distinct policy regimes exercised by the Fed.

Finally, the paper uses a structural VAR model to measure the effects of a shock to FFR on economic growth in Eurozone. The results have important policy implications for monetary authority in Eurozone as it can help them to measure the effects of the shock to U.S. policy interest rate on their economy and enable them to offset those effects by using the appropriate monetary policy response.

The paper proceeds as follows. Section II reviews the literature on the pass-through effect of monetary policy. Section III represents the data, and methodology. Section IV represents the estimated results of econometric models. Finally, Section V offers concluding remarks and policy proposals.

2. Literature Review

Monetary policy affects the economy through a variety of transmission channels, including interest rate. Federal Funds Rate has been the primary focus of the literature on monetary transmission channels. Several studies have attempted to measure the relationship between FFR and other interest rates at the national and international level. However, the majority of empirical studies have focused on the relationship between FFR and domestic interest rates. Using Johansen cointegration and vector error correction models Atesoglu [1,2] and Payne [3] estimate the degree of pass-through effect between FFR and the second rate. Complete pass-through effect occurs if the cointegration coefficient is equal to unity, while incomplete pass-through occurs if the cointegration coefficient is less than one. Both Atesoglu [1] and Payne [3] find a high degree of pass-through effect from FFR into other domestic interest rates.

Estimated results on the relationship between FFR and the prime rate during the sub-periods: 1987:02-1994:01 and 1994:02-2002:05 demonstrate a positive cointegration relationship and a pass-through effect from FFR to the prime interest rate [1]. The results from the first period reveal a bi-directional causality between FFR and the prime rate, while the second period displays a unidirectional causality that runs from the FFR to the prime interest rate.

The empirical results of Atachariyachanvanich on monetary transmission mechanism in Indonesia, Korea, Malaysia, Philippines, and Thailand post financial crisis suggest that asset prices represent the most sensitive variable to the interest rate shocks [8]. The study also indicates the second most sensitive variable is output, followed by real effective exchange rate, and real bank's credit. He finds that despite all the differences in economic structure of these countries, the stock price index represented the most sensitive variable to interest rate shock. Therefore, he concludes that monetary policy transmission channel occurs through stock market.

Several studies in the literature, including Atesoglu have found a cointegration relationship between FFR and long-term interest rates [2]. Distinguishing between the effects of shock in FFR on interest rates in the short-run versus long-run, he demonstrates that in the short-run FFR does not have much effect on long-term interest rates, i.e., in the first 12 months and the peak effect occurs about 30 months later. The results indicate that there is an effect on long-term interest rates; however, the impact is smaller in the short run.

The relationship between FFR and the fixed mortgage interest rate has been the focus of several studies, including Payne [3]. He finds a cointegration relationship between both rates and an incomplete, unidirectional pass-through effect from FFR to the fixed mortgage interest rate. Payne's results undermine Atesoglu [2] by showing that the error correction model indicates a less significant relationship between the mortgage interest rate and FFR in the short-run, while displaying a larger adjustment in the long-run.

Using a Structural Vector Auto Regression (SVAR) model with quarterly data for the period of 1996-2006, Aslanidi [9] indicates that exchange rate channel is more

efficient than interest rate channel in Georgia. He finds domestic interest rate shock has significant impact on Georgian economy compared to external shocks to the U.S. interest rate; the reason is that the domestic interest rate absorbs fluctuations in FFR due to high level of dollarization in Georgian economy. However, his results indicate that a shock to FFR is closely followed by an increase in domestic interest rate; and interest rate reacts strongly to the shocks in FFR.

The relationship between the LIBOR and monetary policy has been the focus of a few studies [10,11]. Fuertes and Heffernan [10] find a sluggish adjustment of loans and deposits' interest rates to changes in the LIBOR, while Ahmad, Aziz, and Rummun [11] find incomplete pass-through effect in the short run, but complete pass-through effect in the long-run.

The monetary transmission channel for GCC countries by Espinoza and Prasad suggest that U.S. monetary policy has a strong and statistically significant impact on broad money, non-oil activity, and inflation [12]. Their results indicate that GCC three month interbank interest rates closely mirrored the U.S. interest rates only in Bahrain and Saudi Arabia; however, the pass-through effect is less than complete in Kuwait, Qatar and Oman. They also find an increase of 100 basis points in Federal Funds Rate decreases broad money growth by 0.6 percentage point and non-oil activity by 0.1 percent.

The effects of monetary policy transmission channel on real output and price level by Atabaev & Ganiyev in Kyrgyzstan, using monthly data for the period of 2003-2011, indicate that the exchange rate channel remains the most effective channel, while interest rate channel is weak and insignificant [13].

To explore the role of monetary policy transmission in China, Kamber and Mohanty [14] construct a new series of monetary policy surprises from financial market data and show that monetary policy surprises have persistent effects on interest rates. They show that a contractionary monetary policy surprise increases interest rates and significantly reduces economic activity.

The relationship between Federal Fund Rate (FFR) and CD rate has been the focus of a study by Nishiyama [4]. He derives the term-structure of CD rates and finds evidence that support the transmission channel from FFR to CDs.

At the international level, the monetary transmission channel from FFR to LIBOR has been the focus of a few studies including Friedman and Shachmurove [5]. Using a cointegration technique and VEC model with quarterly data for two sub-periods of 1987:02-1994:01 and 1994:02-2002:05, they find a significant co-integration relationship between FFR and LIBOR for both sub-periods; however, in the second sub-period the two variables adjust differently to a deviation from equilibrium. In the first period, LIBOR adjusts quickly to changes in FFR, while in the second period the FFR adjusts to changes in LIBOR with a lag. Their findings cast doubt on the ability of Fed to influence other economies through FFR. They conclude that international channel of FFR is weak.

The monetary transmission channel of Fed' policy at international level has also been the focus of a study by Buch, Bussiere, Goldberg and Hills [6]. Using evidence

from seventeen countries the study looks at the spillover effects of monetary policy in major source economies including the euro area, Japan, the U.K. and the U.S. into lending to countries outside the region. They find the transmission of U.S. policy interest rate is statistically significant for nearly all countries. Indeed, a tightening in U.S. monetary policy leads to a large negative change in U.S. denominated lending to the financial sector by banks. However, the transmission channel of monetary policy from other countries seem to be less relevant for most economies. They also distinguish between conventional and unconventional monetary policy periods and find transmission occurs in both periods; but the transmission channel is statistically more significant under unconventional monetary policy.

The transmission channel in four important economies including, China, Japan, EU and US has been the focus of a study by Lombardi, Siklos, and Xie [15]. They find global factors, including interest rates, play an important role and their impact is strongest for China's economy and weakest for Japan. China's impact is significant for Eurozone. They also find no evidence that the financial crisis produced a structural break in the monetary transmission channel at the international level.

One of the novel feature of this study is that it is among a few studies that investigates the pass-through effect of the Federal Funds Rate at international level to LIBOR, distinguishing between two sub-periods of conventional and unconventional monetary policy and expanding the data through 2019:01. It also goes beyond the pass-through effect on LIBOR and measures the effects of a shock to FFR on economic growth in Eurozone by using a structural VAR model.

3. Data and Methodology

This paper investigates the relationship between FFR and LIBOR in two different sub-periods due to different monetary policy implemented by the Fed. The first period relates to the beginning of a major change in the Fed's policy disclosing a target rate for FFR, starting in February 1994 through the financial crisis in 2008:12. The second sub-period covers 2009:01-2019:01, a period of implementing unconventional monetary policy and quantitative easing to see if there is any difference in the size and extent of pass-through effects between these two sub-periods. We use a co-integration technique and Granger causality test to find out the direction of causality between FFR and LIBOR. A Vector Error Correction model is used to measure the size of the effect of a shock to FFR on LIBOR. Finally, we measure the effect of the shock to FFR on GDP growth in Eurozone through a structural VAR model.

3.1. Data

The data consist of monthly time series of two interest rates, the federal funds rate and the LIBOR. The data for these two variables are obtained from the Federal Reserve Economic Data (FRED), a database maintained by the Federal Reserve Bank of St. Louis. The list of variables for estimating the effects of FFR shock on economic growth in Eurozone is presented in Table 1.

Table 1. List of variables

Name of Variable	Definition	Source of Data
GDP	GDP growth in Eurozone	European Central Bank
CPI	Consumer Price Index in Eurozone	European Central Bank
M2	Broad Money Supply in Eurozone	European Central Bank
Int	Real interest rate in Eurozone	European Central Bank
Credit	Domestic Credit by Banks in Eurozone	European Central Bank
REER	Real Effective Exchange Rate	Federal Reserve Bank of St Louis
FFR	Federal Funds Rate	Federal Reserve Bank of St Louis

3.2. Unit Root Tests

Table 2 represents the Augmented Dickey-Fuller (ADF) tests for the FFR and LIBOR under the two sub-periods. When estimated in the level, the unit-root tests reject the assumption of having a unit root, implying that the relationships among the two variables are statistically significant and there exists a long-term relationship between FFR and LIBOR. The estimated results for Granger causality test (Table 3) indicate that the causality runs from FFR to LIBOR under both sub-periods. This finding has important policy implications for monetary authorities in the Eurozone as they can adjust their monetary policy to offset the effects of a shock to FFR on the LIBOR.

Table 2. Unit Root Tests-Augmented Dickey Fuller Test

Variable	Period 1		Period 2	
	t-Statistic	Probability*	t-Statistic	Probability*
FFR	-0.208229	0.9323	-1.888726	0.3364
LIBOR	0.081148	0.9625	-1.872510	0.3440

*MacKinnon (1996) one-sided p-values.

Null Hypothesis Variable has a unit root.

Test critical values: 1% level -3.50, 5% level -2.89, 10% level -2.58.

Table 3. Granger causality test between FFR and LIBOR

Null Hypothesis	Period I (F-statistic)	Period I (Probability)	Period II (F-Statistics)	Period II (Probability)
Libor doesn't Granger cause FFR	6.41	0.0001	8.59	0.0003
FFR doesn't Granger cause LIBOR	1.03	0.27	1.15	0.34

4. Estimated Results

To measure the extent of the effects of FFR on LIBOR we use a Vector Error Correction (VEC) model on the level of the data. The results for the first sub-period presented in Table 4 indicate that there is a positive and significant cointegration relationship between FFR and LIBOR with the magnitude of 0.92, indicating an almost a complete pass-through effect from FFR to LIBOR. The error correction term is not significant for FFR but is significant for LIBOR. This suggests that the LIBOR adjusts in response to FFR to maintain the long run relationship in tandem.

Table 4. Estimation Results of the Vector Error Correction (VEC) Model

Sample Period: 1994:02 through 2008:12				
	Intercept	Federal Funds Rate	Error Correction Term	R ²
OLS	0.272 (3.880)**	0.78 (92.996)		0.97
Johansen	-0.240	0.92 (73.178)**		
FFR			0.044 (0.330)	
LIBOR			0.234 (3.840)**	
Sample Period: 2009:01-2018:01				
	Intercept	Federal Funds Rate	Error Correction Term	R ²
OLS	0.125 (1.695)	0.89 (6.78)**		0.95
Johansen	-0.166	0.98 (60.884)**		
FFR			0.211 (1.46)	
LIBOR			0.501 (7.61)**	

For the second sub-period (2009:01-2018:01), the equilibrium equation has a significant coefficient of 0.99, indicating a one to one relationship between the two variables. However, the two variables adjust differently to deviations from equilibrium: the coefficient on LIBOR is significant, indicating that the LIBOR is adjusting to a deviation from the long-run equilibrium. The coefficient

for FFR is 0.21 and is not significant, but the coefficient on Libor is 0.50 and is significant; in other words, the LIBOR follows the FFR. This conclusion has important policy implications for monetary authorities in Eurozone; as any shock to FFR will be transformed one to one to LIBOR, which in turn, has important effects on investment and economic growth prospects.

Finally, we measure the effects of shocks to FFR on GDP growth of the Eurozone using a structural VAR model. We distinguish between interest rate channel, credit channel and exchange rate channel. The results presented in Table 5 indicate that interest rate channel from FFR to GDP growth ranks second after the credit channel, highlighting the importance of a shock in FFR for economic growth in Eurozone. Based on our results, a 100-percentage point increase in FFR will lead to 0.01 decrease in economic growth in Eurozone. The results support those of Aslanidi [9] who finds the interest rate channel from FFR has a statistically significant effect on economic growth. Indeed, to offset the pass-through effects of a shock in FFR to Eurozone, the monetary authorities need to respond to such a shock by conducting a counter cyclical monetary policy.

Table 5. Structural VAR analysis model with different monetary channels

Different Models	
Direct Monetary Transmission Channel	
GDP	-0.67
M2	-0.09
Exchange Rate Channel	
GDP	-0.71
CPI	-0.81
RER	0.03
Credit Channel	
GDP	-0.83
CPI	-0.02
Credit	-0.05
Interest Rate Chanel	
GDP	-0.78
CPI	-0.03
M2	-0.07
Int	0.03
FFR	0.01

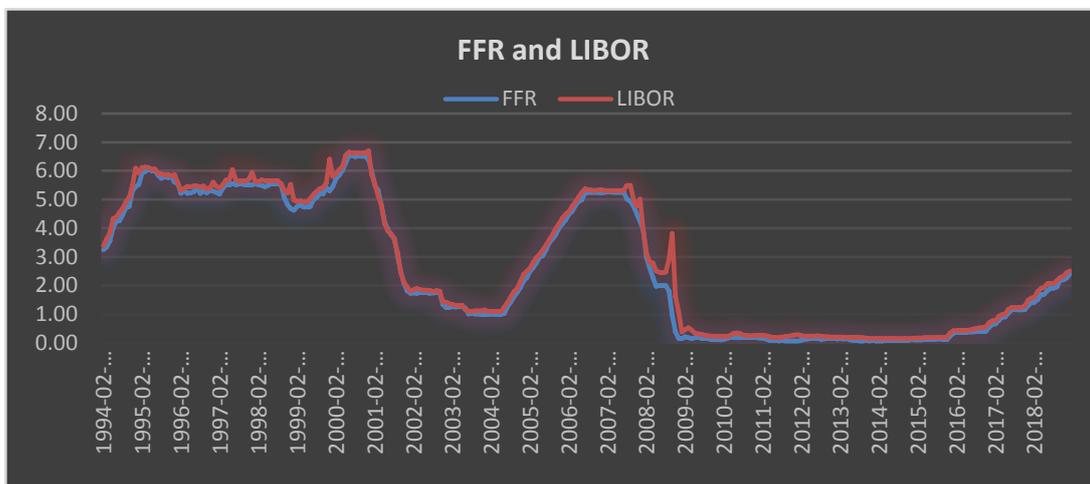


Figure 1. Federal Fund Rate (FFR) and London Interbank Offered Rate

5. Concluding Remarks

This paper extends the research of Atesoglu [1,2], Payne [3], Nishiyama [4], Friedman & Shachmurove [5], Buch, Bussiere, Gioldberg, and Hills [6] by examining the relationship between the Federal Funds Rate (FFR) and London Interbank Offered Rate (LIBOR). Using a co-integration technique and Granger Causality test the study finds that there is a long-term relationship between the two interest rates for the two sub-periods of pre-and post-financial crisis; however, the relationship is stronger for the second sub-period, when the Fed has implemented unconventional monetary policy. The paper finds that in the first sub-period, LIBOR adjusts more slowly to changes in FFR, while during the second sub-period, under unconventional monetary policy, the size of correlation jumps up significantly. The findings highlight the ability of the Fed to influence the world economy and economic growth prospects in Eurozone through monetary transmission channel. Finally, the results for the structural VAR model indicate that FFR channel is the most important transmission channel after the credit channel for economic growth prospect in Eurozone.

The findings of this study are in sharp contrast to those of Friedman, J. & Shachmurove, [5] who find the international monetary transmission channel of FFR is weak. Indeed, as we extend the data to cover the period of unconventional monetary policy, the results indicate that FFR has a strong international channel and there is almost a one to one relationship between FFR and LIBOR. Our results are in accordance with those of Buch, Bussiere, Gioldberg, and Hills [6] who find the transmission channel is strong during unconventional monetary policy. The main conclusion of this paper is that the international monetary transmission channel of FFR is strong enough to have a significant impact on LIBOR and growth prospects of Eurozone as indicated by a few empirical studies.

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