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# THE FEDERAL FUNDS RATE EFFECT ON SUBPRIME MORTGAGE CRISIS MANAGEMENT: AN ARDL APPROACH

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## Abstract

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This research empirically investigated the effectiveness of the interest rate policy of the Federal Reserve (Fed) on managing the subprime mortgage crisis. The study employed the autoregressive distributed lag model (ARDL) to analyze the stability of the Fed's monetary policy, thereby providing an alternative analysis tool. Correlation analysis results showed a strong positive and statistically significant relationship between Fed funds rate and the labor market, a strong negative and statistically significant relationship between Fed funds rate and the housing market, and a strong negative and statistically significant relationship between Fed funds rate and price stability. In contrast, results of the ARDL model bounds test for cointegration indicated that house price index (HPI), labor market, and price stability were cointegrated, hence exhibiting a long-run relationship with Fed funds rate. This research demonstrates that additional empirical studies using new techniques are required to reevaluate the Fisher effect and expand the understanding of the mechanism between interest rates and inflation. This issue is extremely important, particularly for countries such as the U.S., the UK adapting inflation targeting policy using interest rates as an operational target.

**Keywords:** Subprime Mortgage Crisis, FED, Fed Fund Rate, Interest Rate Policy, Monetary Policy, ARDL

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## 1. INTRODUCTION

The interest rate represents an essential tool for performing monetary policy. Central banks and their decisions have different economic impacts as seen in the subprime mortgage crisis (SMC). Following the dot-com bubble, the Federal Reserve (Fed) monetary policy resulted in significant financial

crises after the Great Depression in 1929. Nonetheless, SMC determinants were restricted not only to the Fed policy but also to conventional banking, securitization on corresponding mortgage loans, and credit derivatives that escalated the SMC and costing approximately between US\$5 trillion and US\$15 trillion (Adelson, 2013; Arestis & Karakitsos, 2009).

The SMC started on July 31, 2007, along with the bankruptcy of Bear Stearns. The collapse of Lehman Brothers (the most abundant individual bankruptcy) on September 15, 2008, heightened with the crisis, during which the financial system changed. Goldman Sachs and Morgan Stanley were transformed into commercial banks. Moreover, Fannie Mae and Freddie Mac, which took part in mortgage securitization, were nationalized using US\$200 billion of treasury sources. The spillover effects of the crisis reached other sectors (Gunay & Georgievski, 2018). The SMC sent unprecedented shockwaves worldwide and alarming significant financial and economic indicators. The magnitude of its devastation and the boundary of its effect are unparalleled, such that it has been dubbed the financial tsunami of modern times. A default of a relatively small fraction of mortgage obligors in the U.S. has degenerated into a massive liquidity crisis and credit crunch. The ripple effect of the crisis has threatened 27 national currencies and Europe's global economic powerhouse (Al-Rjoub & Azzam, 2012; Sekmen & Hatipoğlu, 2016).

The patterns preceding the SMC are familiar. They start with economic expansion coupled with low interest rates, stock market activity, and an increase in real-estate prices (Antoniades, 2016; Gunay & Georgievski, 2018). A wrong policy that creates a systematic failure often triggers a crisis. In the case of the SMC, it was triggered by subprime loans designed to target low-income individuals to increase homeownership and, thus, their welfare (Page, 2014). Contrary to intended policy outcomes, this policy resulted in one of the most severe financial crises in human history. The occurrence of the SMC has been attributed to the Fed's low interest rates during that time. Although this period of low interest rates spurred investments, it increased financial market speculations (Li, 2013).

The SMC in 2007 resulted in a drop in equity values and GDB by approximately between US\$10 trillion and US\$12 trillion and 5.25%, respectively, and a temporary decline in household wealth in the U.S. by US\$16 trillion, whereas SMS write-downs were estimated at US\$4.1 trillion (Adelson, 2013). As a response, the government interfered in the market by re-establishing trust in the financial market. First, the U.S. Treasury invested \$700 billion in the Troubled Asset Relief Program (TARP) for purchasing mortgage assets from troubled financial institutions (Mishkin, 2011). Additionally, many central banks and governments worldwide started different financial programs to reduce the effect of the SMC and stop its contagion effects. Other policies included changes in regulation and monetary policy, direct investment in companies, and the adoption of different relief programs (Allen & Carletti, 2010).

The financial system collapse, along with real economic activities, struck the attention of contemporary economists in the period. The authors analyzed different aspects that contributed to the SMC and were affected by it. Therefore, in this study, we empirically investigate the effectiveness of the Fed's interest rate policy SMC management. This investigation significantly contributes to the existing literature in two ways. First, this paper employs a comprehensive list of interaction variables, namely, the Fed funds rate, the U.S. labor market and

housing market, and price stability, to shed light on their cointegrating properties. Second, ARDL methods are employed to analyze the stability of the Fed monetary policy.

The remaining sections of this paper are organized as follows. Section 2 presents the literature review. Section 3 provides theoretical information for the ARDL model used in the empirical analysis. Section 4 reports the main empirical results. Finally, Section 5 draws the conclusion and remarks, implications, and suggestions for further research.

## 2. LITERATURE REVIEW

The collapse of the global financial system had far-reaching effects on financial markets, culminating in the worst economic downturn since the Great Depression of the 1930s. This turn of events caught the interest of contemporary economists who have conducted numerous studies on the global impact of the collapses. Particularly, various studies have analyzed the different aspects that contributed to the SMC and were affected by it. However, despite the intensified research, the current literature on the impact of the Fed policy on economic activities and macroeconomic indicators is scant.

An analysis of the SMC requires a discussion of its main causes, namely, the growth of subprime mortgages, securitization, and adjustable-rate mortgage (ARM). Moreover, the strategy used to mitigate the crisis also requires a discussion. Furthermore, the link between the crisis, economic activity, and macroeconomic goals is essential in the light of this research. The aforementioned points are discussed below.

### 2.1. Causes of the crisis

The first stream of literature claimed that the Fed's mismanaged monetary policy between 2001 and 2003 initially triggered the financial crisis. The low interest rate set by Fed Chair Alan Greenspan contributed to the growth of the housing sector, resulting in a real estate bubble<sup>1</sup> (Page, 2014). Moreover, the ironically low interest rates during this period contributed to the increase in the demand on high-yielding new financial derivatives (Bech, Gambacorta, & Kharroubi, 2014; Srivastava, 2015). Consequently, the interest rates on ARM<sup>2</sup> reduced. As a direct result, banks started competing by reducing their credit requirements. In addition, credit ratings that were disregarded increased demand for housing and housing loans, which inflated housing prices throughout the U.S. (AboElsoud, AlQudah, & Pappas, 2021).

The second line of literature analyzed the links between the SMC and demand-side factors that contributed to the rapid expansion of the U.S. mortgage market. They analyzed the asymmetric causality linkages between credit growth and output growth during the SMC (Dell'Ariccia, Igan, & Laeven, 2012; Moldogaziev & Guzman, 2015; Serwa, 2012). They argued that ignoring borrowers' credit ratings and low mortgage denial rates contributed to

<sup>1</sup> In December 2001, the Federal Reserve Chairman Alan Greenspan lowered the federal fund rate to 1.75 percent. The Fed lowered it again in November 2002 to 1.24 percent.

<sup>2</sup> However, according to the Joint Center for Housing Studies (2008), later ARM increased sharply from 4.5 percent in 2006 to 8.4 percent in 2007 (as cited in Bible & Joiner, 2009).

the growth of credit demand<sup>3</sup>. Moreover, they claimed that lenders in areas with high credit demand growth downplayed candidates' debt-to-income ratios. These results are consistent with the notion that the relaxation of lending standards led to the largest credit boom in U.S. history that triggered the collapse of the market.

The third stream of research argued that securitization was one of the main reasons for the spread of SMC worldwide (Dou, Liu, Richardson, & Vyas, 2014; Le, Narayanan, & Vo, 2016). The securitization of subprime mortgages into collateralized debt obligations and mortgage-backed securities was a major contributing factor to the SMC. Their findings show investors' recognition of the increased credit risk as the SMC progressed and banks' loss of interest in securitization. The major problem was that banks provided ingenious securitizations that offered capital relief but did not transfer the risk, which is the main purpose of the process. Banks failed when real-estate prices collapsed because the risks associated with the securitized mortgages remained on their balance sheets. Their failure was magnified by the absence of insufficient capital during the crisis (Le et al., 2016). Moreover, reflecting on Ryan's (2008) argument that the crisis evolved in waves, issuers of subprime mortgage securities were aware of the increase in and retention of the credit risk by early 2006. Therefore, this finding could indicate that the credit risk retention by the capital market assessment related to securitized assets was inadequate or inaccurate.

The final strand of literature claimed that ARM was one of the causes of the SMC (Bible & Joiner, 2009; OECD, 2015; Pavlov & Wachter, 2011). They explained that ARM had highly unfavorable terms and could worsen after the adjustment period. Aggressive lending instruments increased the price declines in real estate markets. In addition, markets that experienced a decline after the financial crisis and negative demand shock have significantly less loan supply due to aggressive lending withdrawal and predatory lending. Although low short-term rates attracted borrowers to take out mortgages, many borrowers were unable to maintain new higher payments after the mortgage reset (Berger & Frame, 2007). In addition, aggressive mortgage lending increased borrowing. These instruments increased the price of underlying assets because the borrowers' constraints are now relaxed; thus, they can demand the asset. This finding is supported by a line of literature showing that inflated asset prices could be due to underpricing in bank lending risks (Allen & Gale, 1998, 1999; Herring & Wachter, 1999; Pavlov & Wachter, 2011).

## 2.2. Solving the crisis

The Fed decreased the interest rates to solve the SMC. This response to the crisis did not significantly differ from that of the governments and many central banks. They mainly provided extraordinary credits to banks and key firms. Moreover, they recapitalized banks and acquired the majority of ownership in certain banks to mitigate the crisis. Fiscal policy was not an option during the crisis due

to large government borrowings before the crisis. Moreover, policymakers were aware of fiscal policy lags, which will destabilize the economy when they become effective. In addition, conventional monetary policy, including lowering interest rates, was not effective.

Prior to the crisis, prevailing interest rates were low after a period of low inflation levels in several countries. Countries hit the zero-lower bound by lowering the interest rates further. Thus, conventional monetary policy was unable to respond further. Consequently, the Fed used monetary policy tools unconventionally to stimulate economic activity. The central bank opted for further asset purchases on its account despite a zero-bound interest rate. Moreover, it influenced markets' expectations through public statements about the future of monetary policy actions. Friedman (2015) explained that future monetary policy practices will continue to include large-scale asset purchases mainly because central bank activities have reduced long-term interest rates compared with short-term ones. Moreover, they lowered the interest rates on riskier obligations. Blanchard, Dell'Ariccia, and Mauro (2010) and Richter and Dimitrios (2013) stated that central banks should consider using reserve requirements to complement their interest rate policies for the achievement of their macroeconomic objectives. They showed the need for changes in the U.S. and around the world. The U.S. needs a single monetary authority that will react quicker and stronger to adverse economic environmental changes than numerous agencies.

This research discusses the effectiveness of the Fed interest rate on three aspects. First, the U.S. labor market was largely affected by the crisis. During the SMC, the U.S. faced its highest job losses since World War II, leading financial aid programs, such as TARP, to aim at the job market (Goodman & Mance, 2011). A period of stable economic growth and a healthy labor market in 2006 preceded the recession period. According to Goodman and Mance (2011), employment prior to the crisis was concentrated in health, education, and housing market-related industries. The housing market is cyclical and sensitive to economic growth changes. Therefore, this market was hit hard after the occurrence of the crisis, resulting in a drop in U.S. employment. The construction sector lost approximately 57,000 jobs a month (Kelter, 2009). Half of the TARP finance aimed at helping the manufacturing industry, including Chrysler and General Motors, and the financial industry, such as AIG. This activity was mainly done because the manufacturing industry was also adversely affected by the SMC. Furthermore, average monthly job losses rocketed to 73,000 in 2008, totaling to 875,000 in job decline in this sector only in 2008 (Kelter, 2009).

Second, the U.S. housing market is the most sensitive in periods of boom-and-bust cycles. According to the National Association of Home Builders, the U.S. housing market activity (residential investment) contributes approximately 5% to the U.S. GDP. This GDP percentage includes investment in the construction of single and multi-family housing, in addition to remodeling costs and other associated fees, such as brokerage fees. The housing sector is the first to increase when the economy booms. However, it was also the first to decline during

<sup>3</sup> Banks ignored the credit ratings of borrowers and lowered the credit conditions required to increase their own profit.

the SMC due to its policies that primarily caused the SMC. The U.S. homeownership policy and legislation have been an official government policy for decades (Avery & Brevoort, 2015). Homeownership can promote the welfare of low-income households. However, lending low-income borrowers reduced the underwriting standards, hence inflating the housing bubble (Avery & Brevoort, 2015). Furthermore, securitization created a market for securitized mortgages amounting to US\$3.6 trillion. According to the U.S. Census Bureau, this news by the market was accompanied by a period of low interest rate and fraudulent lending practices, which have burst the housing market creating a housing bubble of new unsold homes. In July 2006, 573,000 houses were vacant, which is 50% higher than the previous increase during the saving and loans crisis in 1989 (Keys, Mukherjee, Seru, & Vig, 2010).

Finally, price stability benefits economic growth as it allows investors and consumers to better predict future prices and allocate investments and spending optimally. Therefore, price stability is one of the most important goals of monetary and fiscal policy to support sustainable economic growth rates. Hence, one measure of an effective monetary policy is its ability to manage expected future inflation rates. When inflation is high, it interferes with economic efficiency and thus can reduce economic growth. In addition, when high inflation is expected, reducing inflation can be painful. Financial crises, such as the SMC, can be considered as a natural experiment that tests investors' and consumers' ability to predict future prices and allocate investments and spending. Therefore, the Fed's continued expansionary monetary policy gives rise to speculation whether it can maintain price stability in the coming decades (El-Shagi & Giesen, 2014; Trehan & Zorrilla, 2012).

### 2.3. Impact of the crisis

Recent findings of the analysis of the different aspects affected by the global financial crisis need to be highlighted based on the discussion of the contributing factors of the SMC and the specific solutions. Particularly, the crisis affected the labor market, housing market, and price stability.

Recent findings explained the link between SMC and real economic activity indicators. With respect to the *labor market*, findings showed that the severity of the SMC's impact on the labor market largely depends on the depth of the demand shock, the scale of adjustments in production volume, and the extent of adjustments in wages, working time, and labor productivity (Artha & Haan, 2011; Bryan, 2010; Gaston & Rajaguru, 2015; Kwiatkowski, 2016). Moreover, the International Monetary Fund<sup>4</sup> (2009) showed that the impact of the crisis on the labor market depends on certain institutional factors, such as the employment protection legislation, types of wage bargaining arrangements, and the level and duration of unemployment benefits. Additionally, other studies have shown that the impact varies across countries based on the degree of economic openness, dependence on natural resources, and liberalization of the banking system (Osakwe, Santos-Paulino, & Dogan, 2018).

Regarding the *housing market*, extant literature has shown that it is the most sensitive in periods before and after the financial crisis and economic growth periods promote the real estate market because banks perceive real estate as safe investments. By contrast, households perceive real estate investment as a safe and stable option that increases in demand with increased borrowing easiness (Bardos & Zaiats, 2011; Barkham, 2013). Furthermore, Tran, Hoang, and Tran (2018) stated that the SMC causes liquidity shocks, the large price decline in mortgage markets, large vacancies, and missed investment opportunities. Consequently, the lack of liquidity and investors worldwide influenced markets during the SMC.

*Inflation targeting* is one of the most important tools for controlling the prevailing inflation level in an economy by announcing to the public a quantitative inflation target to be achieved within a certain time (Bernanke, Laubach, Mishkin, & Posen, 1999; Mishkin, 2011). Several studies highlight that inflation targeting is positively correlated with economic performance (Summa & Serrano, 2018). However, countries with flexible inflation targeting regimes could not adjust to desirable inflation levels during the SMC (Chaudhuri, Kim, & Yongcheol, 2016; Fouejieu, 2013; Primus & Mahabir, 2011; Tugcu & Ozturk, 2015). Additionally, price stability cannot sufficiently attain financial stability or prevent the crisis.

The review presented above shows that findings on the impact of the Fed policy on economic activity and macroeconomic indicators are limited, almost non-existing in the literature. The majority of previous research focuses on the causes of SMC and its impact on several markets and evaluations of the policies applied during that time. Hence, this paper aims to fill this gap in the literature. To the best of the researchers' knowledge, this study is the first to investigate the impact of the Fed's interest rate policy on the U.S. labor and housing markets and price stability using a comprehensive list of interaction variables. Section 3 below presents the methodology and data analysis of this study.

## 3. RESEARCH METHODOLOGY

### 3.1. Data collection and transformation

Monthly data for the period from 1993 to 2019 for the U.S. was retrieved from the World Bank Indicators, and the Federal Reserve Bank of St. Louis' Database (FRED). The study primarily uses Pesaran and Shin's (1999), Pesaran, Shin, and Smith's (2001) version of the ARDL model, and following, in particular, the research methodology of Al Qudah, Zouaoui, and Aboelsoud (2020), a theoretical framework of the general macroeconomic model was proposed that takes into consideration the interdependence among the FED monetary policy, housing market, labor market, and price stability. The selected variables consist of the exogenous variable federal fund rate (*FFR*), while endogenous variables are housing price index (*HPI*), labor force participation rate (*LFP*), and consumer price index (*CPI*). No transformation has been done to the data; however, all series are seasonally adjusted.

<sup>4</sup> <https://www.imf.org/external/index.htm>

### 3.2. Empirical framework

As mentioned earlier, this study aims to empirically investigate the effectiveness of the interest rate policy of the Fed funds rate on the housing market, labor market, and price stability using the following three models:

Model 1 represents *HPI* and *FFR* as exogenous and endogenous variables, respectively.

Model 2 represents *LFP* and *FFR* as endogenous and exogenous variables, respectively.

Model 3 represents *CPI* and *FFR* as endogenous and exogenous variables, respectively.

Model 1

$$HPI_t = \beta_{01} + \beta_{11}FFR_t + \varepsilon_{1t} \quad (1)$$

Model 2

$$LFP_t = \beta_{02} + \beta_{12}FFR_t + \varepsilon_{2t} \quad (2)$$

Model 3

$$CPI_t = \beta_{03} + \beta_{13}FFR_t + \varepsilon_{3t} \quad (3)$$

where, *FFR*, *HPI*, *LFP*, and *CPI* are the Fed funds rate, house price index (*HPI*), labor force participation (*LFP*) rate, and consumer price index (*CPI*), respectively,  $\varepsilon_{it}$

is the disturbance terms, which are assumed to be normally distributed and serially uncorrelated,  $\beta_{0i}$  is the model intercepts, and  $\beta_{1i}$  is the *FFR* coefficients in each model.

Models 1-3 represent the relationship of time series (panel) data. Thus, the stationarity of all variables in the model must be tested using the augmented Dickey and Fuller (1979) and Phillips and Perron (1988) tests. Furthermore, the ARDL bounds test (Pesaran et al., 2001) model has been used for a cointegration test.

This approach is not the only advantage of the ARDL model given its several advantages over traditional methods. In addition to estimating the short- and long-run relationships among variables, it considers the endogeneity problem by adding different lags of the dependent and independent variables to the model. The optimal number of lags are selected according to different selection criteria (BIC, Akaike information criterion [AIC],  $R^2$ , and LL) using the vector autoregressive (VAR) model.

The cointegration test results using the ARDL with two models showed long-run relationships in Models 1.1, 2.1, and 3.1 and short-run relationships in Models 1.3, 2.3, and 3.3 through the restricted error correction model (*ECM*).

The long-run relationships of *HPI*, *LFP*, and *CPI* with *FFR* in Models 1-3 using the ARDL bounds approach can be written as follows:

$$HPI_t = \beta_{01} + \sum_{i=1}^{n1} \gamma_{1i}HPI_{t-i} + \sum_{i=0}^{n0} \beta_{11i}FFR_{t-i} + \varepsilon_{1t} \quad (1.1)$$

$$LFP_t = \beta_{02} + \sum_{i=1}^{n2} \gamma_{2i}LFP_{t-i} + \sum_{i=0}^{n0} \beta_{12i}FFR_{t-i} + \varepsilon_{2t} \quad (2.1)$$

$$CPI_t = \beta_{03} + \sum_{i=1}^{n3} \gamma_{3i}CPI_{t-i} + \sum_{i=0}^{n0} \beta_{13i}FFR_{t-i} + \varepsilon_{3t} \quad (3.1)$$

where,  $n_0, \dots, n_3$  are the optimal numbers of lags for each variable using VAR. The ARDL model also provides tools for visualizing the cointegration (long-term) and testing it using the bounds test procedure. The ARDL bounds approach tests for cointegration among variables in all models (Pesaran et al., 2001). It produces F-statistics along

with lower and upper critical values at three different significant levels (1%, 5%, and 10%). The F-test statistics should be above the upper bound to reject the null hypothesis of no cointegration. Then, the ARDL procedure estimates the short-run model (based on Model 2) using the ECM presented as follows:

$$HPI_t = \beta_{01} + \sum_{i=1}^{n1} \gamma_{1i}\Delta HPI_{t-i} + \sum_{i=0}^{n0} \beta_{11i}\Delta FFR_{t-i} + \delta_1 EC_{t-1} + \varepsilon_{1t} \quad (1.2)$$

$$LFP_t = \beta_{02} + \sum_{i=1}^{n2} \gamma_{2i}\Delta LFP_{t-i} + \sum_{i=0}^{n0} \beta_{12i}\Delta FFR_{t-i} + \delta_2 EC_{t-1} + \varepsilon_{2t} \quad (2.2)$$

$$CPI_t = \beta_{03} + \sum_{i=1}^{n3} \gamma_{3i}\Delta CPI_{t-i} + \sum_{i=0}^{n0} \beta_{13i}\Delta FFR_{t-i} + \delta_3 EC_{t-1} + \varepsilon_{3t} \quad (3.2)$$

where,  $\Delta$  is the first difference,  $\delta$ 's are the speed of adjustment parameter of error correction term (ECT)

lagged for one period ( $EC_{t-1}$ ) toward the long-run equilibrium.

Finally, model diagnostic tests were used to check the ARDL model assumptions. All models were checked for serial correlation using the Lagrange multiplier (LM) test, and homoscedasticity was checked by applying the Breusch-Pagan test. Ramsey's regression equation specification error test (RESET) was used for any model misspecification. The stability of the coefficients was checked through the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) of recursive residuals (Bani-Mustafa, Matawie, Finch, Al-Nasser, & Ciavolino, 2019; Brown, Durbin, & Evans, 1975).

## 4. EMPIRICAL ANALYSIS

### 4.1. Descriptive statistics

Table 1 presents the descriptive analysis and correlations of the variables. The descriptive analysis shows the distribution properties of individual variables, whereas the correlation matrix shows the relationship between the variables of interest of the period of study from 1993 to 2019.

**Table 1.** Summary statistics and correlations

	<i>HPI</i>	<i>LFP</i>	<i>CPI</i>	<i>FFR</i>
Mean	139.48	65.29	84.37	2.59
Median	144.79	66.00	85.16	2.00
Maximum	213.84	67.30	109.06	6.54
Minimum	76.79	62.40	60.25	0.07
Standard deviation	40.66	1.64	14.45	2.19
Skewness	-0.10	-0.51	-0.04	0.29
Kurtosis	1.79	1.62	1.67	1.52
Jarque-Bera	20.361	39.992	23.982	34.162
Probability	0.000	0.000	0.000	0.000
Obs.	324	324	324	324
<i>HPI</i>	1.000			
<i>LFP</i>	-0.73	1.000		
<i>CPI</i>	0.90	-0.90	1.000	
<i>FFR</i>	-0.53	0.75	-0.71	1.000

Notes: Variable definitions: *HPI*, *LFP*, *CPI*, and *FFR* are the house price index, labour force participation rate, consumer price index, and federal fund rate, respectively.

Source: Authors' calculations.

Table 1 above shows that the mean, median, measures of dispersion around the mean, skewness, kurtosis, and probabilities of the Jarque-Berra test statistic indicate a normal distribution in the process. Additionally, *FFR* and *LFP* have a strong positive and statistically significant relationship. However, *FFR* and all other variables in this study have a strong negative and statistically significant relationship. Therefore, all the correlation signs are consistent with economic theory.

Moreover, Figure 1 shows the trends of our main variables of interest for the study period of 1993-2019. In the Fed funds rate trend graph, *FFR* started around 3 and jumped to 6 in 1995 and stayed high (above 4) up to mid-2001 before it started to decline (reaching a minimum of 1) up to mid-2004. Subsequently, it started to increase reaching a level of 5 (by mid-2006) before it decreased reaching 0.2 at the end of 2008. It stayed around 0.3 until the end of 2016 before it increased reaching 2.4 in mid-2019. Thereafter, it started to decline to reach a value of 1.6 by the end of 2019. The average *FFR* over the study period was 2.59 with

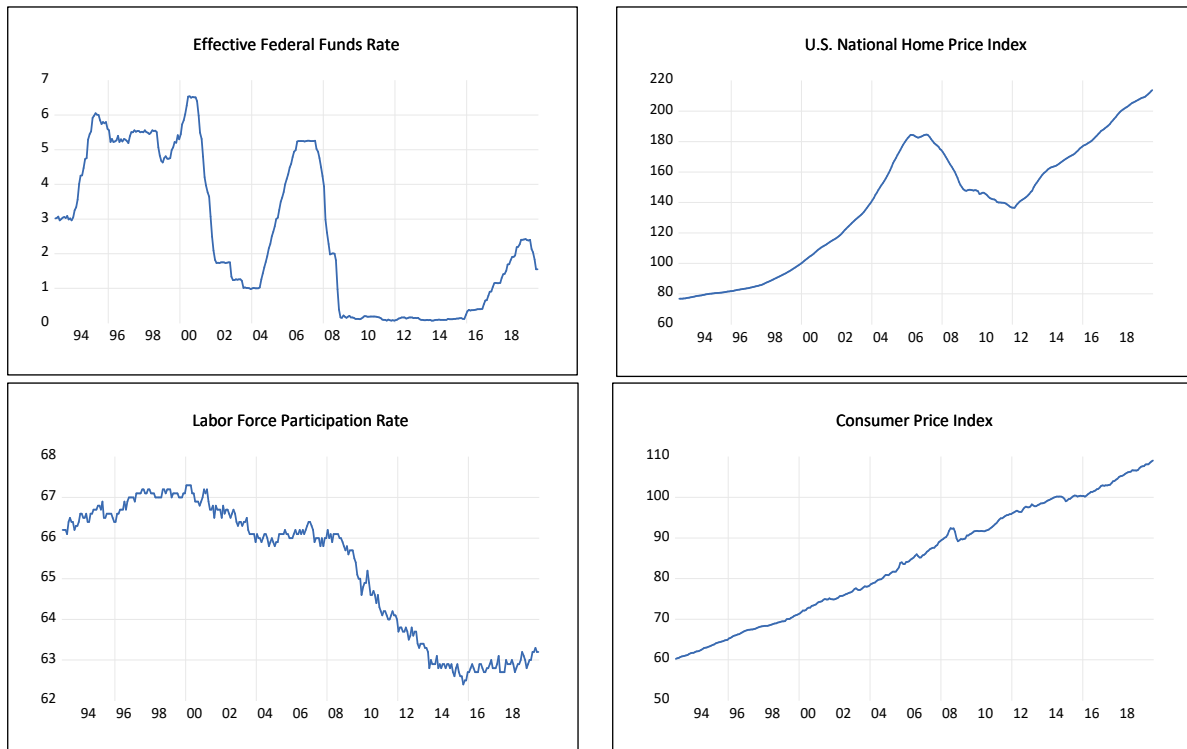
a high standard deviation, minimum, and maximum of 2.19, 0.07, and 6.54, respectively, as illustrated in Table 1.

The *HPI* trend graph shows a quadratic increase reaching a high value of 184 by the end of 2006 before it decreased to 137 at the beginning of 2012. Then, it increased linearly reaching a maximum value of nearly 214 by the end of 2019. The average *HPI* was 139.5 (standard deviation = 40.7), with a range from 76.8 to 213.8.

In contrast, the *LFP* rate trend graph shows that the *LFP* was above 66 with fluctuations until the end of 2008 before it declined, reaching a minimum rate of 62.4 at the end of 2015. Subsequently, it increased gradually reaching 63.2 at the end of 2019. The average *LFP* was 65.29 with a low standard deviation (1.64) that varied between 62.4 and a maximum of 67.3.

The *CPI* trend graph shows almost a straight-line increase during the entire study period, with an average of 84.37 and a standard deviation of 14.45 that ranged between 60.25 and 109.1.

Figure 1. Trend graphs for FED, HPI, LFP, and CPI during 1993–2019



4.2. Unit root test

The unit root tests form one of the essential requirements in time series econometrics because working with non-stationary time series would lead to spurious results in empirical studies due to unstable data representation. Table 2 summarizes

the unit root test results for all variables using ADF and PP tests. Both tests illustrate that all variables are I(1) and none is I(2), which requires checking before applying the ARDL. Pesaran and Pesaran (1997) argued that ARDL results would be biased if any of the variables are stationary at level I(2).

Table 2. ADF and Phillips-Perron unit root tests

Variable	Augmented Dickey-Fuller test		Phillips-Perron test		Order of integration
	Level	First difference	Level	First difference	
	T-value	T-value	T-value	T-value	
HPI	-0.70	-3.16**	2.87	-3.84*	I(1)
LFP	-0.01	-22.25***	-0.07	-22.38***	I(1)
CPI	-0.02	-11.95***	0.02	-10.78***	I(1)
FFR	-1.64	-6.36***	-1.59	-8.67***	I(1)

Notes: \* is significant at 10% level, \*\* at 5% level and \*\*\* at 1% level. Lag orders used in tests are selected automatically according to Akaike information criterion (AIC) and Schwarz information criterion (SIC). Source: Authors' calculations.

The ADF and PP test results in Table 2 affirm that all variables, namely, HPI, LFP, CPI, and FFR, contain unit roots. Thus, all are integrated I(1). These results indicate that the series are integrated in the same order. Therefore, the variables under discussion may have a long-run relationship. Then, the ARDL bounds test (cointegration test) was performed to check the existence of such a relationship.

4.3. Autoregressive distributed lag bounds test (cointegration test)

The ARDL bounds test for cointegration is based on Wald's F-test statistics, with critical values provided

by Pesaran et al. (2001). The best fitted ARDL model is selected automatically based on AIC. The F-test statistics should be more than the upper bound I(1) at a 5% level of significance to have a cointegration.

Table 3 illustrates that the F-test statistics results for the ARDL bounds test for cointegration of our three models are all above the lower bound I0 (3.62) and upper bound I1 (4.16) at a 5% level of significance. Therefore, HPI, labor market, and price stability are cointegrated, that is, they have a long-run relationship with FFR.



**Table 3.** Cointegration ARDL bounds test results

Models with FFR	Wald F-statistics	Adj. R <sup>2</sup>	BG-LM test (p-value)	Ramsey RESET test (p-value)	BP-test homoskedasticity	Outcome
HPI ARDL (10, 1) (Equation 1)	5.44	0.99	0.36 (0.70)	0.44 (0.66)	-1.27 (0.2)	Cointegrated
LFP ARDL (7, 2) (Equation 2)	4.65	0.99	2.21 (0.11)	0.11 (0.91)	1.15 (0.33)	Cointegrated
CPI ARDL (3, 4) (Equation 3)	20.88	0.99	0.15 (0.86)	1.23 (0.22)	0.15 (0.86)	Cointegrated

Source: Authors' calculations.

Equation (1.3) summarizes the long-run HPI (level) equation results with significant coefficients at a 1% level as follows:

$$Cointeq = HPI - (-20.3 FFR + 206.44) \quad (1.3)$$

FFR is negatively and statistically associated with HPI, with a coefficient of -20.3. Therefore, a 1% increase in FFR will decrease HPI by 20.3%.

Equation (2.3) summarizes the long-run labor force (level) equation results, with significant coefficients at a 1% level as follows:

$$Cointeq = LFP - (1.01 FFR + 61.98) \quad (2.3)$$

FFR is positively and statistically associated (in the long run) with labor market index, with a coefficient of 1.01. Therefore, a 1% increase in FFR will increase the LFP rate by 1.01%.

Equation (3.3) summarizes the long-run price stability (level) equation results, with significant coefficients at 1% and 5% levels for the FFR and the constant, respectively, as follows:

$$Cointeq = CPI - (-8.4 FFR + 52) \quad (3.3)$$

FFR is negatively and statistically associated (in the long run) with price stability, with a coefficient of -8.4. Therefore, a 1% increase in FFR will decrease CPI by 8.4%.

All the ARDL models were checked for serial correlation, homoscedasticity, and stability using the LM test, Breusch-Pagan test, and Ramsey's RESET, respectively, as shown in Table 3. All p-values are above the significance level of 5%, indicating a correct ARDL model without autocorrelation, homoscedasticity, stability problems. Hence, our three models are stable and correctly specified.

#### 4.4. Autoregressive distributed lag short-run models

Table 4 summarizes the parameter estimates of our three main short-run ECMs. It summarizes the short-run relationship between FFR and HPI (Model 1), FFR and LFP rate (Model 2), and FFR and CPI (Model 3).

Short-run error correction model (Model 1.2) results show that HPI is significantly and positively associated with a one-month lag of  $\Delta HPI(-1)$  and with  $\Delta HPI(-9)$ . A 1% increase in  $\Delta HPI(-1)$  and  $\Delta HPI(-9)$  will increase HPI by 0.86% and 0.14%, respectively, in the short run. A large change in HPI in the short run is not expected because all coefficients are less than 1. As expected, the  $ECT(-1)$  is negative and significant at the 1% level, with only 0.16% of the monthly speed of convergent toward equilibrium.

Short-run LFP in Model 2.2 shows that LFP is negatively and significantly associated with all lagged differences from 1 to 6 months and with  $\Delta(FFR[-1])$ . LFP is positively associated with  $\Delta(FFR)$ , with a coefficient of 0.14. ECT is also negative and significant at a 1% level, with a 2% monthly speed of convergent toward equilibrium.

The short-run CPI model with FFR (Model 3.2) shows that CPI is negatively and significantly associated with  $\Delta(CPI[-2])$  and  $\Delta(FFR[-3])$ . However, CPI is positively associated with  $\Delta(FFR)$  and  $\Delta(CPI[-1])$ . ECT is not negative but close to zero and significant at a 1% level. This finding indicates that the long-run relationship between CPI and FFR has a structural break. The stability of the estimated parameters using short- and long-run ARDL models (for our three models) is investigated using CUSUM and CUSUMSQ tests to address this issue.

**Table 4.** Short-run coefficient of ARDL models (ECM)

Model 1.2 (HPI), ARDL (10, 1)		Model 2.2 (LFP), ARDL (7, 2)		Model 3.2 (CPI), ARDL (3, 4)	
Variable	Estimates	Variable	Estimates	Variable	Estimates
$\Delta(HPI(-1))$	0.86 (0.057)***	$\Delta(LFP(-1))$	-0.28 (0.056)***	$\Delta(CPI(-1))$	0.47 (0.055)***
$\Delta(HPI(-2))$	0.052 (0.076)	$\Delta(LFP(-2))$	-0.12 (0.057)**	$\Delta(CPI(-2))$	-0.19 (0.055)***
$\Delta(HPI(-3))$	-0.11 (0.057)	$\Delta(LFP(-3))$	-0.12 (0.057)**	$\Delta(FFR)$	0.3 (0.09)***
$\Delta(HPI(-4))$	0.11 (0.075)	$\Delta(LFP(-4))$	-0.15 (0.057)***	$\Delta(FFR(-1))$	0.12 (0.101)
$\Delta(HPI(-5))$	-0.11 (0.075)	$\Delta(LFP(-5))$	-0.14 (0.057)**	$\Delta(FFR(-2))$	-0.065 (0.101)
$\Delta(HPI(-6))$	0.10 (0.075)	$\Delta(LFP(-6))$	-0.09 (0.056)*	$\Delta(FFR(-3))$	-0.25 (0.09)***
$\Delta(HPI(-7))$	-0.10 (0.075)	$\Delta(FER)$	0.14 (0.056)**		
$\Delta(HPI(-8))$	0.05 (0.076)	$\Delta(FER(-1))$	-0.08 (0.057)**		
$\Delta(HPI(-9))$	0.11 (0.058)*				
$\Delta(FER)$	0.14 (0.099)				
$ECT(-1)$	-0.0016 (0.0004)***		-0.02 (0.004)***		0.002 (0.0003)***

Note: \* is significant at 10% level, \*\* at 5% level, and \*\*\* at 1% level. Source: Authors' calculations.

CUSUM and CUSUMSQ graphs (Figure 2) were generated to check the stability of the parameters at a 5% level of significance (red lines) for Model 1. The plots in Figure 2 show that the long-run coefficients are stable and within 5% boundaries. However, this result does not apply to CUSUMSQ, which captured a sudden shift in parameters at the beginning but regained stability (in the long run), within 5% limits. This observation is evidence of structural change in the data and may be due to the 2000 and 2008 financial crises. Therefore, HPI is highly sensitive to financial crisis and FFR.

Figure 3 illustrates the CUSUM and CUSUMSQ graphs for Model 2. The plots show that the long-run

coefficients are stable and within 5% boundaries. Thus, the labor force market is not as sensitive as the home market to the financial crisis.

Finally, Figure 4 illustrates the CUSUM and CUSUMSQ graphs for Model 3. The CUSUM plot shows that the long-run coefficients are stable and within 5% boundaries. However, the CUSUMSQ suddenly shifted at the beginning but regained stability (in the long run) within 5% limits. This finding reveals that the existence of structural change in the data, which may be due to the 2000 and 2008 financial crises.

Figure 2. CUSUM and CUSUMSQ graphs for Model 1

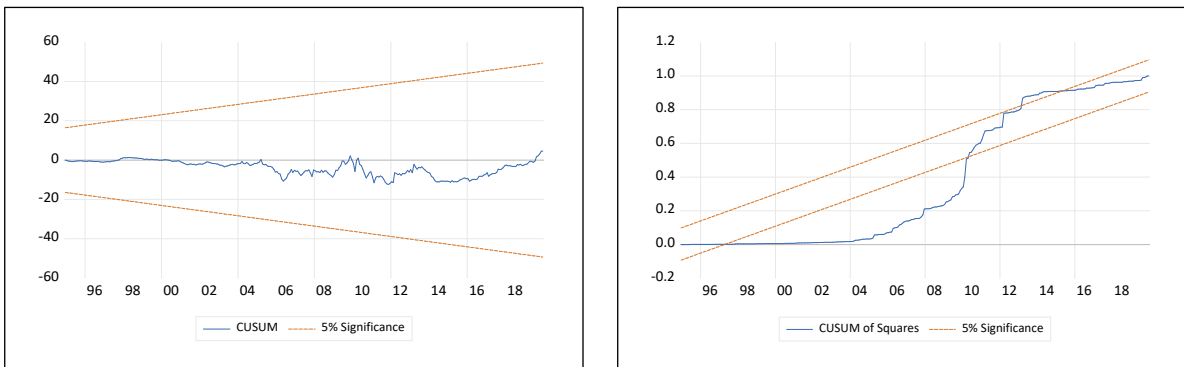


Figure 3. CUSUM and CUSUMSQ graphs for Model 2

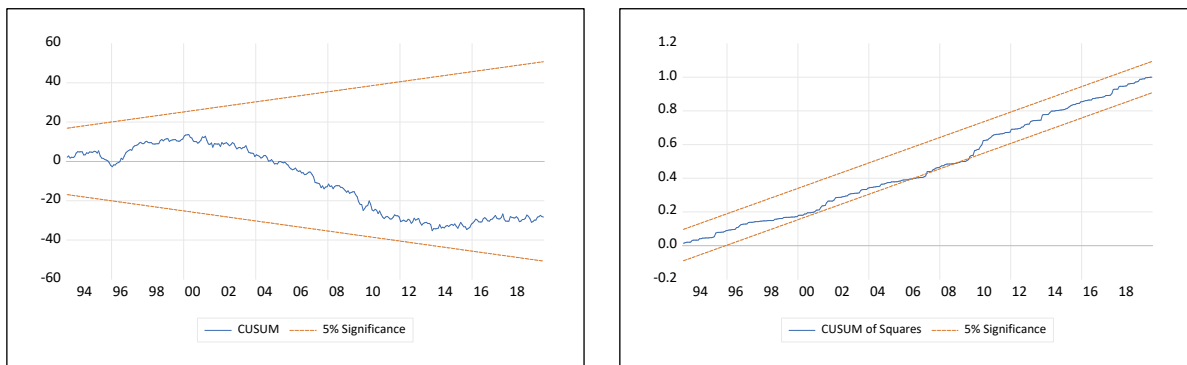
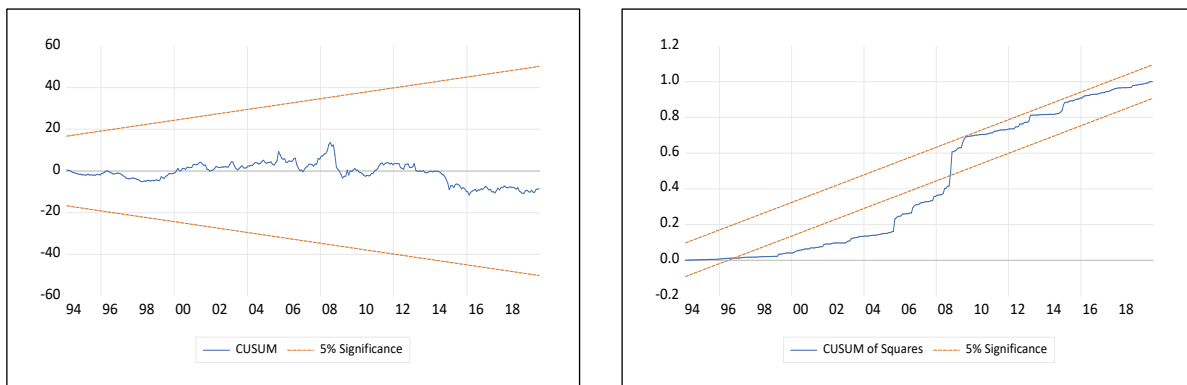


Figure 4. CUSUM and CUSUMSQ graphs for Model 3



## 5. CONCLUSION

This study aimed to empirically investigate the effectiveness of the Fed interest rate policy on SMC management. The study analyzed the effectiveness of interest rate policy of the Fed funds rate on the housing market, labor market, and price stability. Accordingly, the study employed a list of interaction variables, namely, the Fed funds rate, the U.S. labor market, U.S. housing market, and price stability, to examine cointegrating properties between the identified variables. An ARDL model is also used to analyze the stability of the Fed monetary policy.

The correlation analysis results revealed a strong positive and statistically significant relationship between FFR and LFP and a strong negative and statistically significant relationship between FFR and HPI and between FFR and CPI. These findings are consistent with the research expectations and economic theory. Furthermore, the ARDL bounds test results for cointegration indicated that HPI, labor market, and price stability were cointegrated, hence exhibiting a long-run relationship with FFR. The findings revealed a negative and statistically significant relationship between FFR and HPI and between FFR and CPI and a positive and statistically significant relationship between FFR and LPI.

In terms of labor market, this relationship has several explanations, which may be an indirect relationship or due to the small sample size of the analysis. The indirect relationship may be formed by the low interest rates, which enhance the economy through increased lending that reduces the

unemployment level and thus the unemployment-related benefits.

Many researchers have focused on the cointegration relationship between interest rates and the housing sector since the worldwide 2008 financial crisis. However, they ignored the probability of a changing relationship between the examined variables due to a structural break attributed to the global financial crisis. Thus, future studies can include this observation in their analysis.

Understanding the mechanism and relationship between interest rates and inflation is significantly important for effective and timely economic choices of economic actors instituting monetary policy. The Fisher effect suggests that the nominal interest rate and expected inflation rate have a one-on-one positive relationship.

One essential problem is that the federal funds rate was not the only instrument of monetary policy between early 2009 and late 2018; instead, the interest rate paid on required and excess reserve balances was also implemented as a policy instrument. Accordingly, future research will provide more information to policymakers to consider this shift in the Fed's underlying policy regime, which is a particularly significant problem given the small size of the overall sample.

Furthermore, this research demonstrates the need for additional empirical studies using new techniques to reevaluate the Fisher effect and understand the mechanism between interest rates and inflation to a greater extent. This analysis is extremely important, particularly for countries such as the U.S. and the UK, adapting inflation targeting policy using interest rates as an operational target.

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