

# On The Consequences of the Discontinuation of the Eleventh District Cost of Funds Index

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## Abstract

The Federal Home Loan Bank of San Francisco announced its intention to discontinue the three Eleventh District Weighted Average Cost of Funds Indexes (COFI). As these indexes are used to benchmark many ARM mortgages, their discontinuation raises two important issues. First, are mortgage markets losing significant information and efficiency in their absence, and second, does this action result in significant consumer and financial institution costs? Though COFI was somewhat unique when first constructed in 1981, we find that there are now good close substitutes available. In addition, a time series analysis of COFI demonstrates that its quality and time consistency has deteriorated since its inception making it a less useful, and perhaps misleading measure of savings institutions' cost of funds. The analysis also suggests research into the fidelity of other long lived and oft-used indexes is likely warranted.

**Keywords:** Adjustable rate mortgages (ARMs), Cost of Fund Index (COFI), mortgages, interest rates, structural break test

**JEL classification codes:** G01, G21

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## 1. Introduction

On March 31, 1980, the Depository Institutions Regulatory and Monetary Control Act was signed by U.S. President Jimmy Carter. Subsequently, the Federal Home Loan Bank Board approved the issuance of adjustable rate mortgages by its member savings institutions. How they might adjust was to be determined by the institutions. Those institutions expressed a need for a timely metric that would inform consumers as to why adjustments to their adjustable rate mortgages (ARMs) went up or down, and to guide lenders, investors, and consumers in understanding the possible economic consequences of these loans.

At the time, the Federal Home Loan Bank of San Francisco (FHLB-SF) was publishing four semi-annual cost of funds indexes, one each for Arizona, California, Nevada, and one for the entire 11<sup>th</sup> District. To add a timelier metric for the mortgage lending community, one which would be less volatile than current market interest rates, the FHLB-SF began publishing a new index; the 11<sup>th</sup> District Cost of Funds Index (COFI), (Vickroy (1985)). The 11<sup>th</sup> District COFI proved to be popular, and by 1990, 40 percent of all ARM originations nationwide and 70 percent of all 11<sup>th</sup> District ARM originations were tied to the 11<sup>th</sup> District COFI (Passmore (1990)).

In the thirty-eight years since then, much has changed. First, there has been both a consolidation and a change in the structure of savings institutions, and second, competing indexes for ARM adjustments have arrived on the scene. In December 2018, the FHLB-SF announced its intention to terminate the calculation and publication of the 11<sup>th</sup> District COFI by the end of 2021. In general, more market data creates more efficient markets. However, given the nature of the 11<sup>th</sup> District COFI in today's mortgage finance market, the information and efficiency loss with the discontinuation of the 11<sup>th</sup> District COFI is unclear.

To answer this question, we tackle two aspects of the 11<sup>th</sup> District COFI. First, the time series properties of the index are analyzed to ascertain whether or not they have changed over the past several decades. That is, is the index now being discontinued the same index that was originally created in 1981? Second, we examine other existing indexes for their ability to mimic the 11<sup>th</sup> District COFI. To the extent that the 11<sup>th</sup> District COFI can be tracked with other interest rate indexes, then the elimination of it will not result in the market losing information, but will create efficiency gains in the cost saving and simplification of existing market data.

The contributions of this research to the literature are twofold. First, it is the first to analyze the parameter stability of COFI models before and after the 2008/2009 financial crisis. We provide evidence that a significant structural change in interest rates dynamics as captured by this index occurred during the period 2009 to 2010. More generally, it is revealing with respect to how index series might be corrupted by changing underlying economic environments. Second, issuers of adjustable rate mortgages who have relied on the 11<sup>th</sup> District COFI have an economic interest in the consequences of the discontinuation, and by implication, of the relationship of the historical COFI with other potential substitutes.

The article is organized as follows: Section 2 discusses the evolution the index. Section 3 presents the time series properties of the index and models of it. Section 4 presents the time series properties of a Federal COFI model. Section 5 reports the correlation between the 11<sup>th</sup> District COFI and other interest rates, and Section 6 introduces a synthetic COFI using Treasury Yields.

## **2. The Evolution of the 11<sup>th</sup> District COFI**

On April 21, 1981, for the first-time, the Federal Home Loan Bank Board allowed adjustable rate home mortgage loans by federally chartered savings institutions. The loans were to be pegged to an index, though the Board did not specify what index. The goal of this regulatory reform was to enable savings institutions, which typically borrow short-term and lend long-term, to adjust to the high and volatile interest rate market of the late 1970s and early 1980s. By August, it was clear that a stable, published, monthly benchmark rate was needed to relate mortgage interest rates to their cost of funds, and to provide information to the market that could be used to evaluate the attractiveness of these loans. That month, the Federal Home Loan Bank of San Francisco (FHLB-SF), covering Arizona, Nevada, and California, began publishing a monthly index calculated as an average of the cost of funds as reported by 11<sup>th</sup> District member savings institutions. Since that time, the structure and number of 11<sup>th</sup> District member savings institutions has changed dramatically.

The first underlying change relevant to the construction of the 11<sup>th</sup> District COFI was the Savings and Loan (S&L) Crisis of the late 1980s. Previous regulatory reform, which included higher deposit insurance as well as new S&L products, was designed to allow troubled institutions to become profitable. However, it ultimately led to increased risk-taking on the part of these same institutions. The storied meltdown of the S&L industry, beginning in 1988, resulted in sweeping regulatory re-organization and the closure of nearly 800 savings institutions. Thus, the original 11<sup>th</sup> District COFI panel changed in a way that may well have changed the statistical characteristics of the index.

A second important consolidation affecting 11<sup>th</sup> District COFI reporting institutions occurred with bank insolvencies during the 2008/2009 financial crisis. Large savings institutions such as IndyMac and Washington Mutual failed, and while their assets were acquired by other financial institutions, they dropped out of the COFI reporting panel. In all, the panel was reduced to 9 savings institutions in the District.

At its inception in 1981, COFI met a perceived need, and it was statistically stable through the initial period of regulatory change (Cornell (1987), Vickroy (1988)). That a more stable index was required was tested in a simulation study by Berk and Roll (1988). They found a marginal difference between ex-ante valuations of 11<sup>th</sup> District COFI linked ARMs as compared to Treasury rate linked ARMs. Crockett, Nothaft, and Wang (1991), Passmore (1990, 1993), Filimon (1997) and Pericli and Episcopos (1998) studied the ability of econometric models to well predict the 11<sup>th</sup> District COFI. Each study found that though econometric models worked well, the composition of the borrowing and the strategy of the institutions that made up the 11<sup>th</sup> District

COFI reporting panel affected the index responsiveness to movements in Treasury rates, and therefore COFI time series models sometimes had irregularly timed lags. This moderate instability of the index series through the 1980s as a result of the changing regulatory environment clearly had some effect on the ability of 11<sup>th</sup> District COFI linked ARMs to deliver predictable cash flows; one of its original goals. However, these studies did find that another goal, that of reducing interest rate volatility in ARMs, was met. The research cited here was in response to the first episode of consolidation in the thrift industry and has not been revisited since the Great Recession consolidation and concomitant regulatory changes.

More recent research has been oriented toward a more predictable pricing model for financial institutions and consumers. For example, Hancock and Passmore (2016) analyze a series of indexes including the 11<sup>th</sup> District COFI and a “national COFI” that they constructed as the ratio of the total interest expense to total interest-bearing liabilities of commercial banks. They also consider the Freddie Mac Federal COFI index based on US Treasury rates that originated in 1991. From Hancock and Passmore’s study, it is evident that multiple indices of the cost of funds move together, though their new index and the 11<sup>th</sup> District index deviated significantly after 2009. Although these and other studies were not designed to test the economic consequences of the discontinuation of the 11<sup>th</sup> District COFI, they are suggestive that it is no longer the only appropriate indicator for pricing and valuing ARMs, and that possibly no unique information embodied in the 11<sup>th</sup> District COFI would be lost were it to be discontinued. These are the issues explored below.

### 3. Time Series Properties of 11<sup>th</sup> District COFI Models

#### 3.1. General Series Characteristics

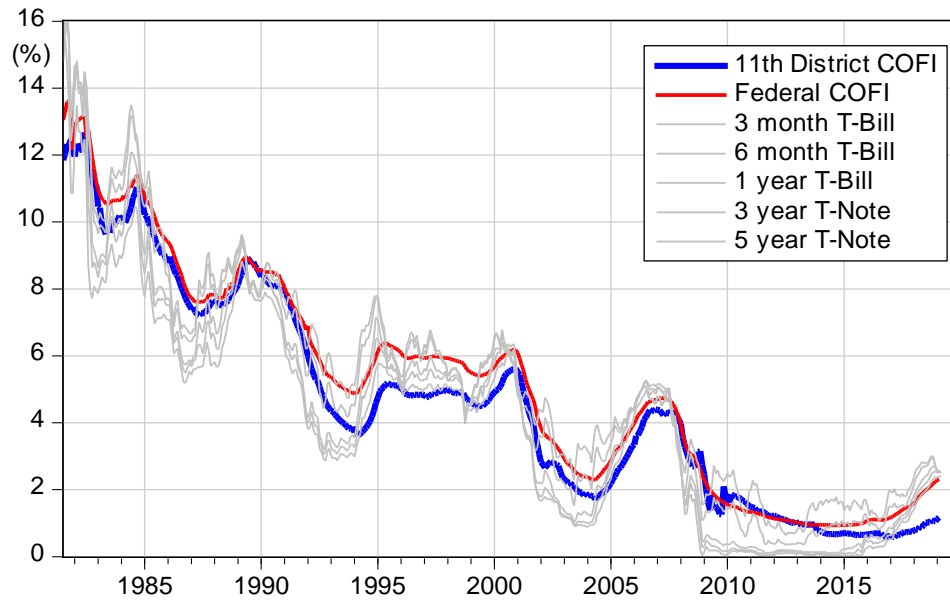
The 11<sup>th</sup> District COFI is computed from the actual interest expense reported each month to the FHLB-SF by select member savings institutions from Arizona, California, and Nevada; institutions that satisfied the Bank’s specific criteria for inclusion in the 11<sup>th</sup> District COFI. It is calculated as:

$$COFI_t = \frac{I_t}{\frac{B_t + B_{t-1}}{2}} \times \frac{365}{12 \times D_m} \times 12 \quad (1)$$

where  $B_t$  is the end-of-month balance for funds in month  $t$ ,  $I_t$  is the interest expenses paid on the funds for various maturities of deposits, and  $D_m$  is the number of days in a given month. A days-in-the-month adjustment is made to make interest expenses comparable across months. The 11<sup>th</sup> District COFI (Figure 1, thick line) follows the general trend of Treasury interest rates. However, the 11<sup>th</sup> District COFI is, by design, less volatile. This is achieved by using an average of current and past rates.

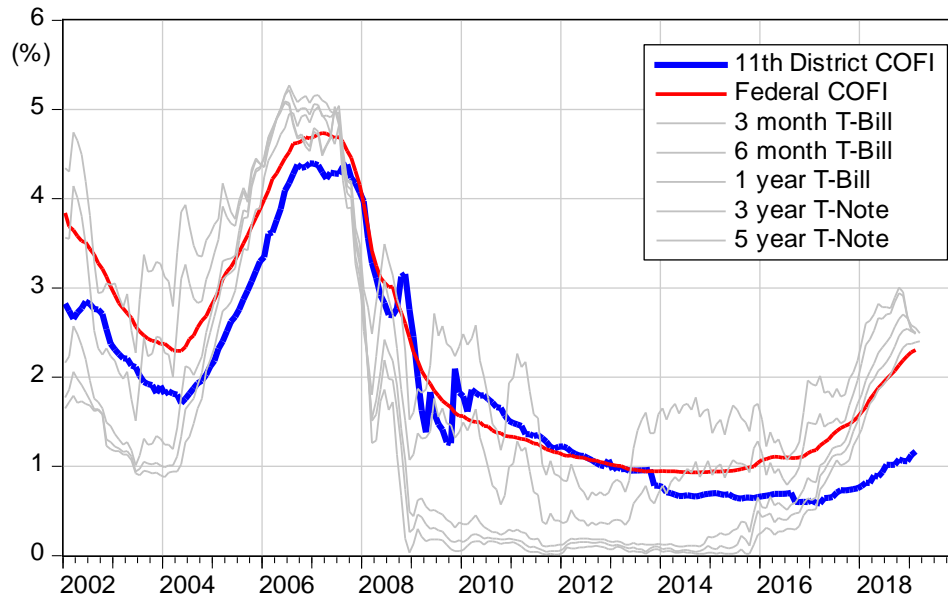
Also shown in Figure 1 is a metric computed and published by Freddie Mac entitled Federal COFI (Thin dark line). This is constructed as the sum of the monthly average interest rates for marketable Treasury bills and Treasury notes. Though Federal COFI tracks the 11<sup>th</sup> District COFI relatively well from 1981 to 2014, the Federal COFI values are generally higher.

**Figure 1. 11<sup>th</sup> District COFI, Federal COFI, and Other Interest Rates, 1981 to 2019**



Sources: Federal Reserve, Federal Home Loan Bank of San Francisco, and Freddie Mac

**Figure 2. 11<sup>th</sup> District COFI, Federal COFI, and Other Interest Rates, 2002 to 2019**



Sources: Federal Reserve, Federal Home Loan Bank of San Francisco, and Freddie Mac

Figure 2 zeros in on the critical time frame, 2002-2018. The smoothness in the earlier Federal COFI index continues through this period, however, the 11<sup>th</sup> District COFI becomes more volatile after 2006. For example, there is a jump from 1.3% in October 2009 to 2.1% in November 2009, and a drop of 0.2 percentage points in November 2013. More importantly, the Federal COFI index and all of the Treasury rates rose at approximately the same average rate in 2017 and 2018, but the 11<sup>th</sup> District COFI’s rate of increase was substantially lower.

### 3.2. Structural Break Tests

The issue of consistency for the series is best thought of as consistent in its relation to other relevant time series. Were that relationship to be broken, then the statistical evidence would point to the 11<sup>th</sup> District COFI as representing different underlying economic behavior. Although both late in the 1980s and 2008/2009 are historical break-points in the series, we take an agnostic approach to the question of statistical break-points, and analyze the 11<sup>th</sup> District COFI time series properties with several structural break tests for two COFI index models. These are the partial adjustment model and the portfolio adjustment model, and both assume at the outset unknown breakpoints. In other words, we are letting data decide whether there are structural break(s) in the parameters of the 11<sup>th</sup> District COFI models and if so, when would they be. The break tests employed are described in this section.

An early version of a structural break test employed here is the Chow Break Test (1960), which fits an equation separately for an assumed known break date, and tests whether or not there are significant differences across the hypothesized single break in the series. The *F*-statistic is based on the restricted and unrestricted sum of squared residuals:

$$F = \frac{(\hat{\mu}'\hat{\mu}) - (\mu_1'\mu_1 + \mu_2'\mu_2)/k}{(\mu_1'\mu_1 + \mu_2'\mu_2)/(T-2k)} \quad (2)$$

where  $\hat{\mu}'\hat{\mu}$  is the restricted sum of squared residuals,  $\mu_i'\mu_i$  is the sum of squared residuals from subsample  $i$ ,  $T$  is the total number of observations, and  $k$  is the number of parameters in the equation. Andrews (1993) extended the Chow Test by assuming the break-date is unknown, and uses the data to identify if any structural breaks occur. Andrews Break-point test is a sequence of single Chow Break-point tests at each sequential pair of dates,  $\tau_1$  and  $\tau_2$ . For each individual Chow Break Test, the same  $F$ -statistic as found in the Chow Test is retained. A maximum  $F$ -statistic is then calculated as:

$$MaxF = Max_{\tau_1 \leq \tau \leq \tau_2} F(\tau) \quad (3)$$

The Andrews Break Test identifies as the break-point the  $\tau$  that maximizes (3). Because the test is sensitive to end points, the first and last 15% of the sample are excluded.

Bai and Perron (1998, 2003) further extend the Andrews Break-point test by allowing for multiple unknown breakpoints. Consider a standard multiple linear regression model with  $T$  periods and  $m$  potential breaks (producing  $m + 1$  regimes), the regression model is:

$$y_t = X_t'\beta + Z_t'\delta_j + \varepsilon_t \quad (4)$$

for the regimes  $j = 0, \dots, m$ . The  $X$  variables are those with time-invariant parameters across regimes, while the  $Z$  variables have coefficients that are regime specific. The  $m$  multiple breaks are identified by minimizing the sums-of-squared residuals of the regression model:

$$S(\beta, \delta | T_1, \dots, T_m) = \sum_{j=0}^m \left\{ \sum_{t=T_j}^{T_{j+1}-1} y_t - X_t'\beta - Z_t'\delta_j \right\}^2 \quad (5)$$

Bai and Perron (2003) provide algorithms for computing the global optimizers for multiple breakpoint models. The multiple break test is in fact a generalization of the Andrews Break Test, in which the null of no breaks is tested against an alternative of  $l$  breaks. An  $F$ -statistic is used to evaluate the null hypothesis that  $\delta_0 = \delta_1 = \dots = \delta_{l+1}$ . In the analysis herein, we tested using both the Andrews single break test and the Bai and Perron multiple break test.

Although Bai and Perron's test is more general and subsumes Andrew's test, the two have different statistical properties. Both rely on asymptotic distributions for inference. However, when more than one break is tested, the interior segment of the time series cannot, by definition, increase in the number of observations as is required for the asymptotic probability distribution of the test statistic. The use of the asymptotic distribution in the Bai and Perron test relies on the interior segments to be "large enough" to approximate the asymptote. The Andrew's test, not having an interior segment, therefore, is less likely to reject a true null

hypothesis of no breaks than the Bai and Perron test. As a robustness test, both are presented below.

### 3.3. The Partial Adjustment Model

The first of the two models analyzed for consistency is the partial adjustment model (Cornell (1987), Passmore (1993), Stanton and Wallace (1994)):

$$COFI_t = \alpha + \beta_1 COFI_{t-1} + \beta_2 T_t + \beta_3 FEB_t + \beta_4 D31_t \quad (6)$$

where  $T_t$  is the one-year Treasury rate,  $FEB_t$  is a February fixed-effect variable, and  $D31_t$  is the fixed-effect variable for months with 31 days. The model assumes that the long-term cost of funds is linearly related to the 1-year Treasury rate, and that in the short run, the cost of funds partially adjusts toward its long-run equilibrium. The rationale for the fixed-effect variables is that some member thrifts used a 360-day year with 30-days of interest occurring each month regardless of the actual length of the month. In those cases the COFI days-in-the-month adjustment over or understates the actual cost of funds.

The first column of Table 1 presents the estimated parameter coefficients of the partial adjustment model for the entire sample period, August 1981 to February 2019. If these parameter estimates are stable over the past four decades during which time the average funds covered declined from \$334 billion with 152 reporting members to \$19 billion with 9 reporting members (Figure 3), then one would expect the estimated coefficients from sub-periods to be similar to those in the first column of Table 1. In fact, there are significant coefficient differences between the sub-period model estimates.

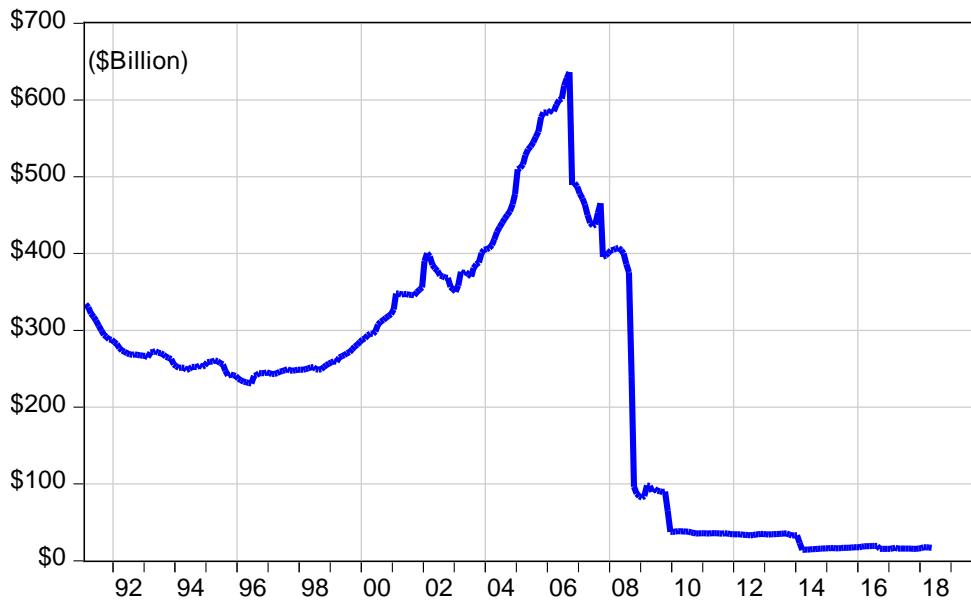
**Table 1. Partial Adjustment Model Regressions: 11<sup>th</sup> District COFI**

| Variable        | Full Sample<br>1981m8-2019m2 | Sub-period<br>1981m8-1991m3 | Sub-period<br>1991m4-2010m3 | Sub-period<br>2010m4-2019m2 |
|-----------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|
| $COFI_{t-1}$    | 0.92***<br>(0.01)            | 0.87***<br>(0.01)           | 0.89***<br>(0.01)           | 0.97***<br>(0.01)           |
| One-year T-Bill | 0.07***<br>(0.01)            | 0.09***<br>(0.01)           | 0.09***<br>(0.01)           | 0.02***<br>(0.01)           |
| Constant        | 0.04***<br>(0.02)            | 0.43***<br>(0.07)           | 0.09**<br>(0.04)            | 0.00<br>(0.01)              |
| February        | 0.002<br>(0.02)              | 0.07***<br>(0.03)           | -0.04<br>(0.03)             | 0.01<br>(0.01)              |
| 31-Day          | -0.04***<br>(0.01)           | -0.11***<br>(0.02)          | -0.02<br>(0.01)             | 0.01<br>(0.01)              |
| Adj. R-squared  | 0.99                         | 0.99                        | 0.99                        | 0.99                        |
| N               | 451                          | 116                         | 228                         | 107                         |

Note: Standard error in parenthesis with HAC Newey-West standard errors. \* Statistically significant at 10% level. \*\* Statistically significant at 5% level. \*\*\* Statistically significant at 1% level.



**Figure 3. Average Funds Balance for 11<sup>th</sup> District COFI Reporting Members**



Source: Federal Home Loan Bank of San Francisco

**Table 2. Bai and Perron Multiple Structural Break Test: Partial Adjustment Model 11<sup>th</sup> District COFI**

| No. of Breaks | F-statistic | Scaled F-statistic | Critical Value | Break Dates |
|---------------|-------------|--------------------|----------------|-------------|
| 0 vs 1 **     | 15.96       | 79.79              | 18.23          | 1991m03     |
| 1 vs 2 **     | 19.1        | 95.5               | 19.91          | 2010m03     |
| 2 vs. 3       | 3.5         | 17.51              | 20.99          | N/A         |

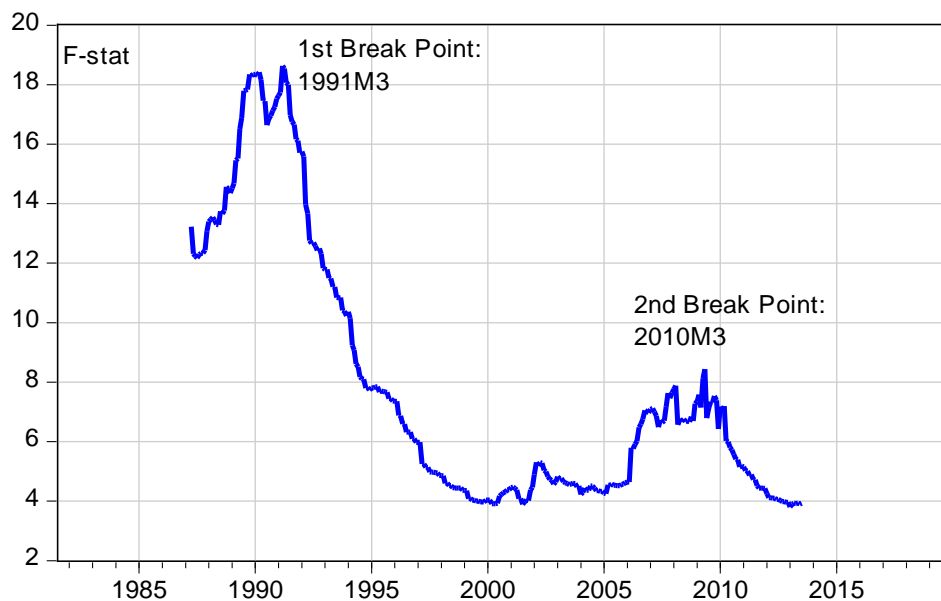
\*\* Statistically significant at 5% level.

The sequential *F*-statistic break test as shown in Table 2 indicates that two breaks occurred in the partial adjustment model: The first occurred in March 1991 and the second occurred in March 2010. These correspond to the aforementioned consolidations in the thrift industry and the regulatory changes accompanying them during and shortly after the S&L Crisis and the Great Recession.

To test for robustness, we also consider the alternative Andrews Break Test with an unknown single structural break. Figure 4 shows the *F*-statistic for each possible month under the assumption of an absence of a single structural break in the series. There are two local maximum *F*-statistics (1991 and 2010), which confirms the results found with the Bai and Perron test.

**Figure 4. Andrews Single Structural Break-test: Partial Adjustment Model**

**11<sup>th</sup> District COFI**



Source: Authors' calculation

Based on the results from these two statistical tests, the sample was divided into the three sub-periods previously discussed (Table 1). The model was estimated for each sub-period separately: (1) 1981m8-1991m3, (2) 1991m4-2010m4, (3) 2010m5-2019m2. The coefficient estimates are found in Columns 2-4 of Table 1. For sub-periods 1 and 2, the coefficients for the lagged COFI (0.87, 0.89) and 1-year Treasury rates (0.09, 0.09) are very similar though the increase in the lagged COFI coefficient was statistically significant. Possible instability in the intercept and the calendar fixed-effect coefficients was observed. The estimates of the parameters here are similar to those in the earlier studies of Cornell (1987) and Passmore (1993). Though a break in the statistical properties of the series is clearly detected, to the extent that it changed the qualitative character of the time series, that change was relatively small.

However, the estimated coefficients move significantly between sub-period 2 and sub-period 3. The coefficient of lagged COFI increased from 0.89 to 0.97, implying that the COFI series was more closely that of a unit-root or non-stationary data series than before. The coefficient for the 1-year Treasury variable plummeted from 0.09 to 0.02. Thus, the fundamental characteristic of COFI as an index capturing smoothed movements in interest rates as measured by U.S. Treasury yields abated after 2010. Between the second and third break period, the interest-bearing liabilities sampled in COFI plummeted. This statistical analysis is strong evidence that the composition and structure of these funds are now fundamentally different than that of the pre-2010 period.

### 3.4. The Portfolio Adjustment Model

A second model for analyzing the 11<sup>th</sup> District COFI time series is the portfolio acquisition model of Roll (1987):

$$DCOFI_t = \alpha + \beta_1 DTCOFI_{t-1} + \beta_2 DT_t + \beta_3 FEB_t + \beta_4 D31_t \quad (7)$$

Where  $DTCOFI_{t-1} = T_{t-1} - COFI_{t-1}$ . The  $DTCOFI_{t-1}$  represents the difference between lagged market costs and book costs, and the estimated coefficient on this variable will be an estimate of the speed of adjustment. The last difference in the equation is the change in one-year T-Bill rates:  $DT_t = T_t - T_{t-1}$ . The portfolio model addresses one concern with the partial adjustment model; that COFI and other interest rates might exhibit statistical nonstationary properties. The first column of Table 3 presents the parameter estimates of the portfolio model.

Table 4 presents the multiple break tests of the portfolio model. The tests yield a break in May 1989, and another in May 2009. Figure 5 displays the Andrews Break Test. The timing of the structural breaks is not far from those identified for the partial adjustment model: (1) May 1989 vs March 1991 and (2) May 2009 vs March 2010. The most probable break in the portfolio series occurs in May 2009 consistent with the plunge in the average fund balance as shown in Figure 3.

With these two breakpoints, we once again divide the sample into three periods: (1) 1981m9-1989m5, (2) 1989m6-2009m5, (3) 2009m6-2019m2. Columns 2-4 of Table 3 are the estimates on the sub-periods identified by the break tests on the portfolio adjustment model. We find that for the first two sub-periods, the model adjusted R-squared estimates are 0.49 and 0.53. But, for the period in the aftermath of the financial crisis, the adjusted R-squared is a minimal 0.03. This implies that what was perhaps a good model of the cost of funds for savings institutions as a smoothed interest rate index broke down with the consolidation in the industry associated with the last recession.

**Table 3. Portfolio Adjustment Model Regressions: 11<sup>th</sup> District COFI**

| Variable       | Full Sample        | Sub-period         | Sub-period        | Sub-period        |
|----------------|--------------------|--------------------|-------------------|-------------------|
|                | 1981m9-2019m2      | 1981m9-1989m5      | 1989m6-2009m5     | 2009m6-2019m2     |
| $DTCOFI_{t-1}$ | 0.07***<br>(0.01)  | 0.08***<br>(0.01)  | 0.09***<br>(0.01) | 0.03***<br>(0.01) |
| $DT_t$         | 0.10***<br>(0.04)  | 0.11**<br>(0.05)   | 0.04<br>(0.03)    | -0.19<br>(0.19)   |
| Constant       | 0.01<br>(0.01)     | 0.06***<br>(0.02)  | -0.01<br>(0.01)   | 0.02<br>(0.03)    |
| February       | 0.000<br>(0.00)    | 0.07**<br>(0.03)   | -0.01<br>(0.03)   | -0.02<br>(0.03)   |
| 31 Day         | -0.04***<br>(0.01) | -0.13***<br>(0.03) | -0.02**<br>(0.01) | -0.01<br>(0.02)   |
| Adj. R-squared | 0.35               | 0.49               | 0.53              | 0.03              |
| N              | 450                | 93                 | 240               | 117               |

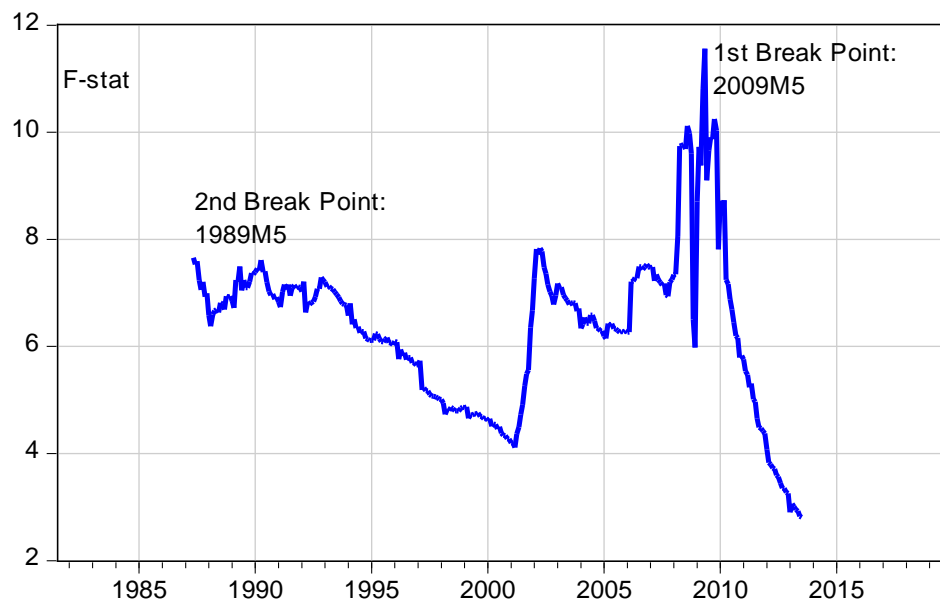
Note: Standard error in parenthesis with HAC Newey-West standard errors. \* Statistically significant at 10% level. \*\* Statistically significant at 5% level. \*\*\* Statistically significant at 1% level.

**Table 4. Bai and Perron Multiple Structural Break Test: Portfolio Adjustment Model 11<sup>th</sup> District COFI**

| No. of Breaks Test | F-statistic | Scaled F-statistic | Critical Value | Break Dates |
|--------------------|-------------|--------------------|----------------|-------------|
| 0 vs 1 **          | 15.15       | 79.73              | 18.23          | 1989m05     |
| 1 vs 2 **          | 10.1        | 95.5               | 19.91          | 2009m05     |
| 2 vs. 3            | 2.8         | 14.13              | 20.99          | N/A         |

\*\* Statistically significant at 5% level.

**Figure 5. Andrews Single Structural Break Test: Portfolio Adjustment Model  
11<sup>th</sup> District COFI**



Source: Authors' calculation

#### 4. Time Series Properties of The Federal COFI

One interpretation of the structural changes found in the previous section is that they are not strictly a characteristic of the 11<sup>th</sup> District COFI, but are a more general structural change in interest rate dynamics. Certainly, the Federal Reserve's policy of Quantitative Easing during and after the Great Recession impacted Treasury rates in a different way than previous interest rate policy. To examine this possibility, we study the same ARM-index models but with another index: the Federal COFI published by Freddie Mac. This index is computed as a weighted Treasury interest rate index, and recent history is displayed in Figure 1.

Table 5 presents the estimated coefficients using the partial adjustment model for the Federal COFI index. The coefficients are similar to those of the 11<sup>th</sup> District COFI prior to the financial crisis of 2008/2009. Table 6 presents the multiple structural break results. Note that there are no breaks identified. The Andrews *F*-statistic also does not find structural change either during or after the Great Recession. This is unlike the results for the 11<sup>th</sup> District COFI over the same time frame.

Table 7 presents the estimated coefficients using the portfolio adjustment model for the Federal COFI index. Table 8 presents the multiple structural break results. In this analysis, a structural breakpoint in September 2009 is found. We use this break date to divide the sample into two periods: (1) Pre-2009 and (2) Post-2009. The estimated coefficients are given in Columns 2 and 3 of Table 7. Unlike the estimated model for the 11<sup>th</sup> District COFI (Table 3)

where the adjusted R-squared dropped across the breakpoint, the estimated Federal COFI model has an increase in the adjusted R-squared from 0.44 to 0.86. Thus, the model actually fits better after the breakpoint of 2009, rather than worse as is the case with the 11<sup>th</sup> District COFI. These empirical findings confirm that the change in the character, information content, and nature of the 11<sup>th</sup> District COFI from its inception to today is related to the change in the composition and behavior of the savings institutions in the 11<sup>th</sup> District COFI sample and not more general interest rate dynamics.

**Table 5. Partial Adjustment Model Regression: Federal COFI**

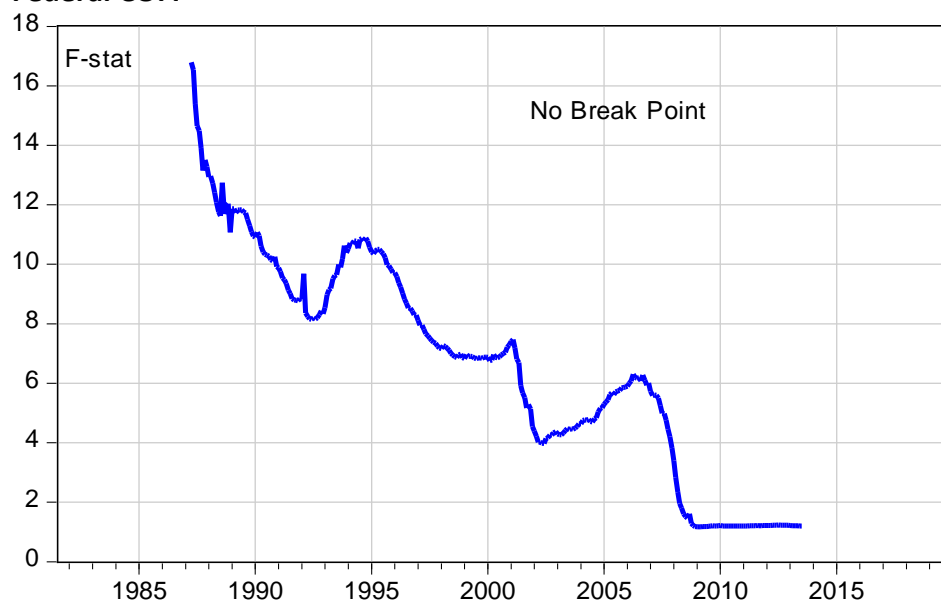
| Variable             | Full Sample<br>1981m8-2019m2 |
|----------------------|------------------------------|
| $COFI_{t-1}$         | 0.91***<br>(0.01)            |
| One-year<br>Treasury | 0.09***<br>(0.01)            |
| Constant             | 0.07***<br>(0.01)            |
| February             | -0.003<br>(0.01)             |
| 31 Day               | 0.01<br>(0.00)               |
| Adj. R-squared       | 0.99                         |
| N                    | 451                          |

Note: Standard error in parenthesis with HAC Newey-West standard errors. \*\*\* Statistically significant at 1% level.

**Table 6. Bai and Perron Multiple Structural Break Test: Partial Adjustment Model Federal COFI**

| Break<br>Test | F-statistic | Scaled F-<br>statistic | Critical Value | Break Dates |
|---------------|-------------|------------------------|----------------|-------------|
| 0 vs 1        | 3.17        | 15.83                  | 18.23          | N/A         |

**Figure 6. Andrews Single Structural Break Test: Partial Adjustment Model  
Federal COFI**



Source: Authors' calculation

**Table 7. Portfolio Adjustment Model Regressions: Federal COFI**

| Variable       | Full Sample       | Sub-period        | Sub-period        |
|----------------|-------------------|-------------------|-------------------|
|                | 1981m9-2019m2     | 1981m9-2009m9     | 2009m10-2019m2    |
| $DTCOFI_{t-1}$ | 0.08***<br>(0.01) | 0.08***<br>(0.01) | 0.05***<br>(0.01) |
| $DT_t$         | 0.13***<br>(0.01) | 0.13**<br>(0.01)  | 0.08***<br>(0.02) |
| Constant       | 0.03***<br>(0.01) | 0.03***<br>(0.01) | 0.03***<br>(0.00) |
| February       | -0.007<br>(0.01)  | -0.01<br>(0.01)   | -0.00<br>(0.00)   |
| 31 Day         | 0.01<br>(0.01)    | 0.01<br>(0.01)    | 0.00<br>(0.00)    |
| Adj. R-squared | 0.45              | 0.44              | 0.86              |
| N              | 450               | 337               | 113               |

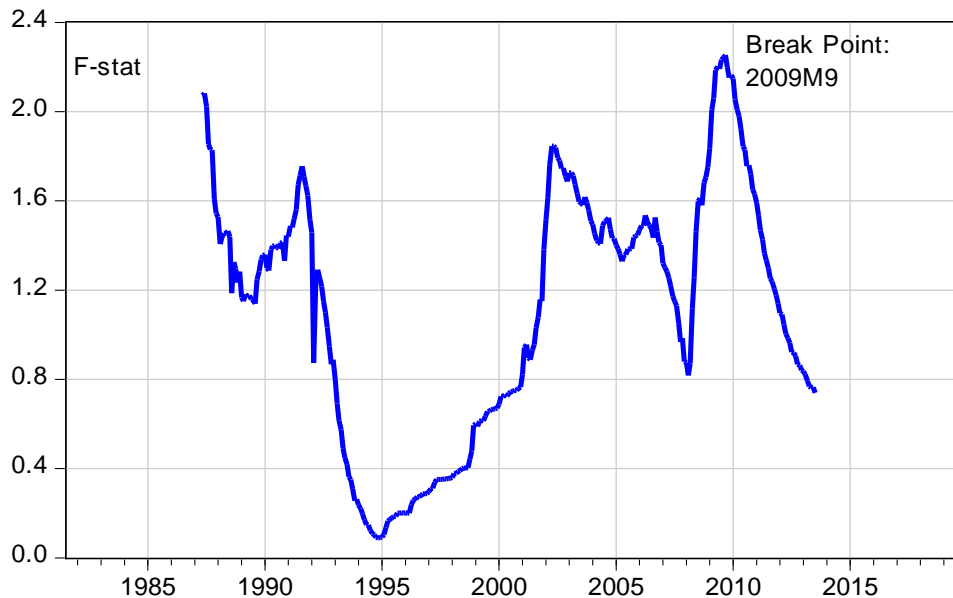
Note: Standard error in parenthesis with HAC Newey-West standard errors. \* Statistically significant at 10% level. \*\* Statistically significant at 5% level. \*\*\* Statistically significant at 1% level.

**Table 8. Bai and Perron Multiple Structural Break Test: Portfolio Adjustment Model  
Federal COFI**

| Break Test | F-statistic | Scaled F-statistic | Critical Value | Break Dates |
|------------|-------------|--------------------|----------------|-------------|
| 0 vs. 1 ** | 9.77        | 48.86              | 18.23          | 2009m09     |
| 1 vs. 2    | 0.69        | 3.47               | 19.91          | N/A         |

\*\* Statistically significant at 5% level.

**Figure 7. Andrews Single Structural Break Test: Portfolio Adjustment Model  
Federal COFI**



Source: Authors' calculation

## 5. Correlation Properties

The construction of the 11<sup>th</sup> District COFI is based on the reported actual interest expenses by the COFI panel institutions. With a rolling fraction of old deposit contracts with older interest rates combined with new deposits contracts with more recent interest rates, the 11<sup>th</sup> District COFI should exhibit a correlation with a moving average of market interest rates. In Table 9, the relationship between 11<sup>th</sup> District COFI and the 12-month moving average of one-year Treasury bill rates, another popular benchmark in the ARM housing market, is examined. The first Column shows the period from 1981 to 1991; prior to the first structural break identified earlier. During this period the 11<sup>th</sup> District COFI was highly correlated with the 12-month



moving average 1-year Treasury bill index with a correlation of 0.92. When adjusted for the fixed-effect variables the R-squared is 0.63.

Column 2 exhibits the period from 1991 to 2010. The coefficient of the 12-month moving average of the 1-year Treasury bill index was statistically the same as in the prior period at 0.9, and the adjusted R-squared increased to 0.87. Column 3 shows the period after the Great Recession. The coefficient of the moving average Treasury bill rate index dropped to 0.36, and more importantly, the negative adjusted R-squared indicates no correlation between the two series in this period. The evidence re-confirms what was found previously: the 11<sup>th</sup> District COFI is very different before and after the 2008/2009 recession with respect to other widely used indexes for ARMs.

**Table 9. 1-Year Moving Average Treasury Rate Model Regressions  
11<sup>th</sup> District COFI**

| Variable       | Sub-period<br>1981m7-1991m3 | Sub-period<br>1991m4-2010m3 | Sub-period<br>2010m4-2019m2 | Sub-period<br>1981m7-2010m3 |
|----------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| 12M MA         | 0.92***                     | 0.90***                     | 0.36***                     | 0.93***                     |
| 1-Year T-Bill  | (0.03)                      | (0.02)                      | (0.01)                      | (0.02)                      |
| February       | 0.67**                      | 0.30**                      | 0.69***                     | 0.31**                      |
|                | (0.28)                      | (0.12)                      | (0.12)                      | (0.14)                      |
| 31 Day         | 0.58***                     | 0.31***                     | 0.75***                     | 0.28***                     |
|                | (0.15)                      | (0.08)                      | (0.08)                      | (0.01)                      |
| Adj. R-squared | 0.63                        | 0.87                        | -2.4                        | 0.94                        |
| N              | 117                         | 228                         | 107                         | 345                         |

Note: Standard error in parenthesis with HAC Newey-West standard errors. \* Statistically significant at 10% level. \*\* Statistically significant at 5% level. \*\*\* Statistically significant at 1% level.

In Table 10, a more complete set of maturities of Treasury yields is examined. This includes a common set of interest rates across the yield curve: a 3-month moving average of the 3-month Treasury Bill, a 6-month moving average of the 6-month Treasury bill, a 12-month moving average of the 1-year Treasury bill, a 36-month moving average of the 3-year Treasury note, and a 60-month moving average of the 5-year Treasury note. For simplicity, we use the entire period before the 2010 breakpoint<sup>4</sup>. Column 1 of Table 10 shows most Treasury yields are significantly correlated with the 11<sup>th</sup> District COFI except for the 3-month Treasury Bill rate and the February fixed-effect.

Column 2 presents a re-estimation of the model dropping the 3-month Treasury bill rate variable and the February fixed-effect variable. In both specifications, the behavior of the 11<sup>th</sup> District COFI prior to the structural break associated with the savings bank consolidation of

<sup>4</sup> We estimate the model with the term structure for the period after 2010 as well. The result shows a poor fit, in which no Treasury yields are significantly correlated to the 11<sup>th</sup> District COFI with the exception of the moving average of 5-year Treasury yields.

2008 to 2010 is closely related to the term structure of interest rates. Consequently, the information with respect to the cost of funds originally embodied in the 11<sup>th</sup> District COFI, is duplicated through other metrics in the market.

**Table 10. Multiple Moving Average Treasury Rate Model Regressions  
11<sup>th</sup> District COFI, 1982:6 to 2010:3**

| Variable             | Consider All Possible Treasury Rates | Include Only Statistically Significant Variables |
|----------------------|--------------------------------------|--|
| 3M MA 3-M T-Bill     | -0.03<br>(0.13)                      |  |
| 6M MA 6-M T-Bill     | 0.38**<br>(0.18)                     | 0.35***<br>(0.07)                                |
| 12M MA 1-Year T-Bill | 0.24**<br>(0.10)                     | 0.25***<br>(0.08)                                |
| 36M MA 3-Year T-Note | 0.21**<br>(0.08)                     | 0.22***<br>(0.08)                                |
| 60M MA 5-Year T-Note | 0.15**<br>(0.06)                     | 0.14**<br>(0.06)                                 |
| February             | -0.08<br>(0.06)                      |  |
| 31 Day               | -0.13***<br>(0.03)                   | -0.12***<br>(0.03)                               |
| Adj. R-squared       | 0.98                                 | 0.98   |
| N                    | 334                                  | 334  |

Note: Standard error in parenthesis with HAC Newey-West standard errors. \* Statistically significant at 10% level. \*\* Statistically significant at 5% level. \*\*\* Statistically significant at 1% level.

## 6. A Synthetic COFI From Treasury Yields

Based on Column 4 of Table 9 and Column 2 of Table 10, one can construct an index to mimic the 11<sup>th</sup> District COFI prior to the Great Recession. The synthetic COFI index can then be extended to the period after the Great Recession. To construct a simple index using only the 12-month moving average of the 1-year Treasury Bill rate, we simply apply the previously estimated correlation coefficient **0.93** of it to mimic 11<sup>th</sup> District COFI. There is no need to consider February and 31-day month fixed effects in this construct. For a more comprehensive index, we consider four significant maturities of Treasury yields: the 6-month, the 1-year, the 3-year, and the 5-year Treasury yields. The weights for each are based on the previous coefficient estimation and are normalized to 100 percent (Table 11).

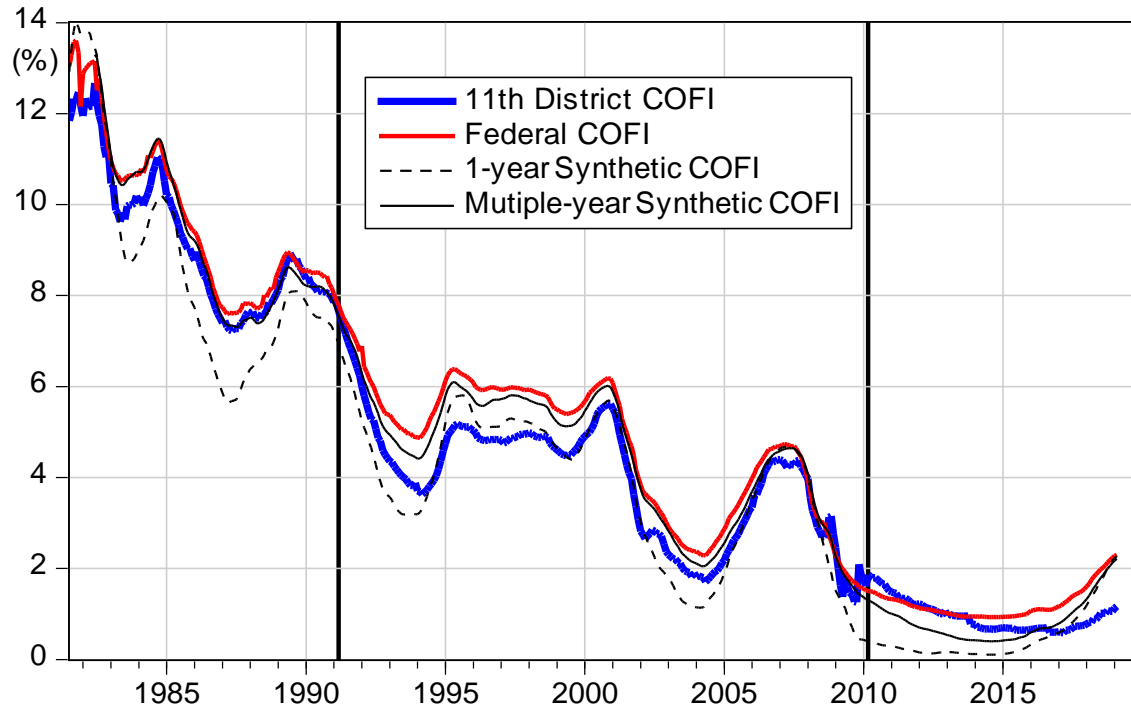
**Table 11. Weight and Component of Synthetic COFI**

| Component                                       | Weight      |
|---|-------------|
| 6-month moving average of 6-month Treasury bill | <b>0.35</b> |
| 12-month moving average of 1-year Treasury bill | <b>0.25</b> |
| 36-month moving average of 3-year Treasury bill | <b>0.25</b> |
| 60-month moving average of 5-year Treasury bill | <b>0.15</b> |

Source: Authors' calculation

Figure 8 displays the 11<sup>th</sup> District COFI, Federal COFI, 1-year Synthetic COFI, and multiple-year synthetic COFI. It is clear that 1-year synthetic COFI is inferior to multiple-year synthetic COFI in capturing the dynamics of the 11<sup>th</sup> District COFI prior to 2010. The multiple-year synthetic COFI follows more closely the Federal COFI as well, particularly during the period 1991 to 2001. Thus, two alternatives (Federal COFI and the multiple-year synthetic COFI) can be used as a replacement for the 11<sup>th</sup> District COFI with no significant loss of information content relative to the information provided by the 11<sup>th</sup> District COFI prior to 2008.

**Figure 8. Comparisons of COFI, Federal COFI, 1-year Synthetic COFI, and Multiple-year Synthetic COFI**



Sources: Federal Home Loan Bank of San Francisco, Freddie Mac and authors' calculation

## 7. Conclusions

This study examines the time series properties of the 11<sup>th</sup> District Cost of Funds Index in light of the discontinuation of the index in the near future. The first question we asked was: Is the 11<sup>th</sup> District COFI today the same as it was in the past? There have been dramatic changes in the composition of the reporting panel for the 11<sup>th</sup> District COFI as well as in the financial institution regulatory environment during the life of this index. Our analysis demonstrated that these changes have resulted in an index decidedly different from that embodied in the 1981 construct. The second question we asked was, regardless of whether or not the properties of the index have changed, is it still providing information about the evolution of interest rates in the market that absent the publication of COFI would be lost? The analysis demonstrated that the information provided by the 11<sup>th</sup> District COFI (prior to its deterioration after 2009) can be well provided by a number of alternative indexes, and therefore no significant information would be lost with the discontinuation of the 11<sup>th</sup> District COFI. Consequently, the cost of the discontinuation of the 11<sup>th</sup> District COFI for the mortgage market is minimal. While this study is specifically centered on the discontinuation of the 11<sup>th</sup> District COFI, is it instructive with regard to the long run use of indexes and their temporal stability in general.

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