The Dynamics of Interest Rates and Housing Prices at the National and Regional Level

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I. Introduction

The relationship between interest rates and housing prices appears simple but may be far more complex than initially thought. One would expect the dynamic between the two variables to be facilitated by the federal funds rate, various mortgage rates, and the costs of purchasing housing. If the federal funds rate increases, then mortgage rates likely increase, for overnight borrowing between banks becomes more expensive and thus requires banks to increase the rates on their various loan products to meet the rising cost of borrowing. As such, mortgage rates increase as the federal funds rate increases. Higher mortgage rates increase the costs of purchasing housing because of the more expensive mortgage financing. Consequently, the demand for housing falls, and thus housing prices fall. The relationship, then, seems to exhibit some negative association as the two variables move in opposite directions.

However, the direction of causation may not be so clear. In the case of purchasing housing through mortgage financing, some uncertainty exists regarding the causality among the federal funds rate, mortgage rates, and housing prices. One might think that the Federal Reserve sets targets for the federal funds rate that then affect housing prices by means of mortgage rates,

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but what if the Federal Reserve considers housing prices in setting targets for the federal funds rate, reversing the direction of the relationship? On a related note, to what extent do banks adjust their mortgage rates in response to changes in the federal funds rate, and to what extent do banks consider housing prices when setting their mortgage rates?

Several other factors may play a role in the relationship between interest rates and housing prices. So far, the discussion has only examined the demand side of the housing market; how do demand *and* supply interact in response to a change in the federal funds rate? A decrease in the federal funds rate increases the demand for housing and creates upward price pressure, but given the relatively constant cost of construction materials, rising housing prices likely lead to an increase in the supply of housing, thus creating downward price pressure. The net equilibrium result depends upon the dynamic between demand and supply and the elasticity of each, the latter of which invites a discussion of regional factors in the housing market. Regions with more interest sensitive construction industries might exhibit greater elasticity than those with less interest sensitive industries. Demographic factors also affect the demand and supply sides. While national factors play a role, these regional factors may shape the housing market more notably.

II. Literature Review

The relationship between interest rates—principally the Federal Reserve's federal funds rate—and housing prices stands at the forefront of recent economic discussions regarding monetary policy, the housing bubble, and the Great Recession. In his 2010 speech titled "Monetary Policy and the Housing Bubble," former Chairman Ben Bernanke directly addresses the question of whether years of accommodative monetary policy and a correspondingly low federal funds rate contributed to conditions that caused the most recent recession. Although he acknowledges that a comparison of the actual federal funds rate to the suggested Taylor rule

federal feds rate indicates that monetary policy was too accommodative, Bernanke suggests that it is difficult to attribute the crisis, at least with regards to the housing bubble, to the actions of the Federal Reserve alone. Regardless, the conversation raises questions concerning the relationship between interest rates and housing prices. Do interest rates affect housing prices one-to-one, or is there somewhat of a reverse causality in that interest rates are set after examining prices, which include housing prices? Moreover, do interest rates affect housing prices alone, or are there regional factors that confound and complicate the relationship between interest rates and housing prices?

In examining the relationship, one must first establish the underlying economic phenomenon that explains the movements of interest rates and housing prices. Taylor explores a simple relationship in "Housing and Monetary Policy": higher interest rates increase the cost of mortgage financing, thus decreasing the demand for housing (more expensive than before, causing a negative substitution effect) and consequently lowering prices; lower interest rates decrease the cost of mortgage financing, increasing the demand for housing (less expensive than before, causing a positive substitution effect) and raising prices (2007). In "Monetary Policy, Housing, and Heterogeneous Regional Markets," Fratantoni and Schuh also posit a strong inverse relationship between monetary policy, via the federal funds rate, and housing activity (2003). While both Taylor and Fratantoni et al. discuss the importance of how interest rates affect housing prices on a time lag, Fratantoni et al. accounts for changes in housing prices as being influenced by both national and regional factors, suggesting that housing supply and demand provide one specific instance of how local markets determine prices.

In the literature, researchers fall along a spectrum attributing housing prices to national factors, regional factors, or a combination of the two. On one hand, Reichert in "The impact of

interest rates, income, and employment upon regional housing prices" argues that certain local economic and demographic factors affect regional markets uniquely (1990). In this regard, Reichert posits the housing market as heterogeneous and places larger value on variables measured at the local level: migration patterns, distribution of minorities and the elderly, changes in population relative to national levels, and changes in real income. On the other hand, Abraham and Hendershott in "Bubbles in Metropolitan Housing Markets" focus upon a lagged appreciation rate that occurs at the local level in speculative bubbles but with less emphasis on demographic factors and the federal funds rate (1994). Essentially, Abraham et al. argue that bubbles are a local phenomenon that occurs as gaps develop between the actual and equilibrium housing prices.

Explanations citing a combination of the federal funds rate at the national level and factors at the regional level appear the most reasonable. In "99 Luftballons: Monetary policy and the house price boom across US states," Del Negro and Otrok begin their discussion by posing the question of whether the increase in housing prices is a national phenomenon or a result of local bubbles—that is, caused by monetary policy or regional circumstances (2007). Ultimately, Del Negro et al. arrive at the conclusion that the effect of the federal funds rate is non-negligible but small enough that regional factors play a sizable role in influencing housing prices. The extent or magnitude of change is specifically attributed to states' exposure to the business cycle. Similarly, Carlino and DeFina in "Do states respond differently to changes in monetary policy" study states' responsiveness to changes in monetary policy, analyzing discrepancies and their causes (1998). Carlino et al. also argue that state economies with a higher proportion of interest sensitive industries exhibit greater responsiveness to changes in monetary policy. Because housing construction tends to be very interest sensitive, it seems that states with greater housing

growth experience more of the effects brought on by changes in interest rates. This finding coincides with much of the existing literature that the federal funds rate plays a role and additionally posits that the extent is then determined by factors at the regional level.

For the most part, the literature seems to agree that the federal funds rate alone does not exhibit a one-to-one relationship with housing prices. While different opinions exist regarding the extent of the relationship, there appears to be a consensus that the federal funds rate does affect housing prices in addition to several regional factors, ranging from the demographics of the local populace and changes to said population to the supply and demand of housing in local markets and the nature of states' economies. These factors provide potential explanations for a more nuanced relationship that allows both national and regional influences on housing prices. However, some limitations exist. For example, the literature suggests that each region itself acts uniformly, but this assumption potentially neglects how different regions have locales that react differently from the overall region. In other words, housing markets may exhibit greater heterogeneity than expected, albeit with influences from the federal funds rate, such that regional analysis will require smaller partitions. This paper will specifically examine the regional context of the San Francisco Bay Area – in addition to national housing prices – to evaluate the relationship between interest rates and housing prices while also considering regional factors.

III. Data Sources

In examining interest rates and housing prices, there are several data sources to consider. Beginning with the former, the federal funds rate set by the Federal Open Market Committee seems to have some sort of relationship with housing prices. Federal funds rate data may be obtained via the Federal Reserve Bank of St. Louis' Economic Research Division webpage[2]. The

[2] https://research.stlouisfed.org/fred2/series/FEDFUNDS

federal funds rate—the overnight interest rate between depository institutions—is expressed as a percent, released monthly, and not seasonally adjusted. Although data on the federal funds rate exists before January 1975, only values from this month and year onward will be examined given the availability of other data sources in this paper.

Similarly, mortgage rates have a close relationship with housing prices, related by the costs of financing home purchases. Freddie Mac's Primary Mortgage Market Survey (PMMS)[3] collects data from 125 lenders each week on rates and points for their most popular 30-year fixed rate, 15-year fixed rate, and 5/1 hybrid amortizing adjustable rate mortgage products. The survey is based on first-lien prime conventional conforming home purchase mortgages with a loan-to-value of 80 percent, and lenders include institutions such as thrifts, credit unions, commercial banks, and mortgage lending companies. Since the Federal Reserve Bank includes the average 30-year rate on its list of Selected Interest Rates, the 30-year fixed rate will be examined in this paper. Available data begins in April 1971, and regional rates begin in March 1976, the latter of which may be of use in examining regional aspects of the relationship.

Housing prices will be examined principally via data from the S&P/Case-Shiller US National Home Price Index[4]. The index captures the total value of existing single-family housing and tracks changes in the value of residential real estate nationally. As the index excludes newly constructed properties and properties that cannot be identified as single-family, any changes reflect a constant level of quality and thus avoid biasing index values. The Case-Shiller US National Home Price Index is calculated monthly by aggregating nine US census division[5] repeat-sales indices, constructed from data on properties that have sold at least twice, to capture

[3] http://www.freddiemac.com/pmms/pmms_archives.html
[4] https://fred.stlouisfed.org/Case-Shiller
[5] The divisions include New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific.

the true appreciated value of each specific sales unit while holding quality and size constant. However, the index may be vulnerable to an upward bias if homes sold repeatedly tend to be newer and higher in value than older homes that turn over less frequently. Sales accumulate in rolling three-month periods, so an index value for a single month contains data from the previous two months in addition to the single month itself. The index has data available from January 1975 onward using back testing under the same methodology.

Additionally, housing prices will also be examined via the S&P/Case-Shiller Home Price Indices, which measures average change in home prices in various geographic markets. Like the national index, the home price indices are calculated monthly via the same methodology but cover 20 major metropolitan areas with price tiers (low, middle, high). Altogether, the various areas aggregate to form composites, one with 10 areas and the other with all 20. Unlike the national index and its earliest available data in January 1975, the home price indices only have data available beginning in January 1980. As previously mentioned, the availability of data at both the national and regional level will be of great import in examining the relationship between the variables in question. Consequently, the San Francisco Home Price Index will be included in addition to the National Home Price Index.

More specific data from Zillow on regional housing prices will also be included. The single-family time series tracks the monthly median home value for single family housing in various geographic regions: neighborhood, ZIP code, city, congressional district, county, metropolitan area, state, and nation. In this regard, Zillow provides more data to consider in analyzing the relationship between interest rates and housing prices at the regional level. As such, this paper will examine index values from neighborhoods in the San Francisco Bay Area to

account for potential regional factors. Note that Zillow does not exclude newly constructed properties and includes sale prices for all homes regardless of whether they have been sold. Below is a summary table and time series plots of relevant variables.

Table 1: Descriptive statistics

Variable	Observations	Mean	S.D.	Min	Max
Federal Funds Rate	165.00	5.26	3.98	0.07	17.78
Mortgage Rate	179.00	8.35	3.10	3.36	17.74
Mortgage Rate (West)	160.00	8.39	3.31	3.32	17.62
National Housing Prices	167.00	97.77	48.51	25.30	184.42
San Francisco Housing Prices	119.00	123.41	54.98	47.37	225.26
Zillow Neighborhood Prices	243.00	255166.30	130215.80	62733.32	757766.60
GDP Deflator	164.00	73.65	22.59	30.60	110.29
Unemployment Rate	165.00	6.49	1.57	3.90	10.67

Figure 1: Evolution of interest rates

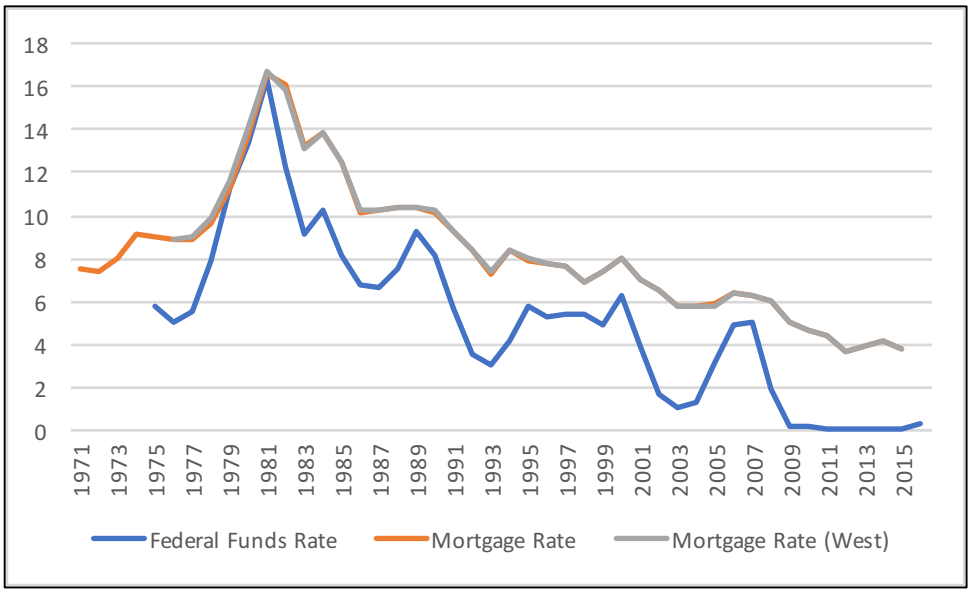


Figure 2: Evolution of Case-Shiller Housing Prices

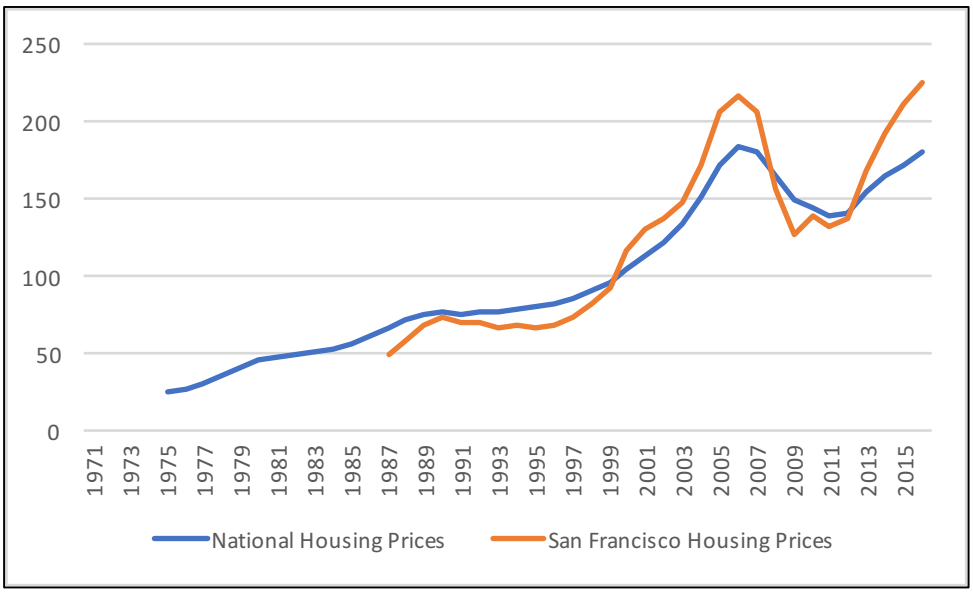


Figure 3: Evolution of Zillow Housing Prices (in ten thousands)

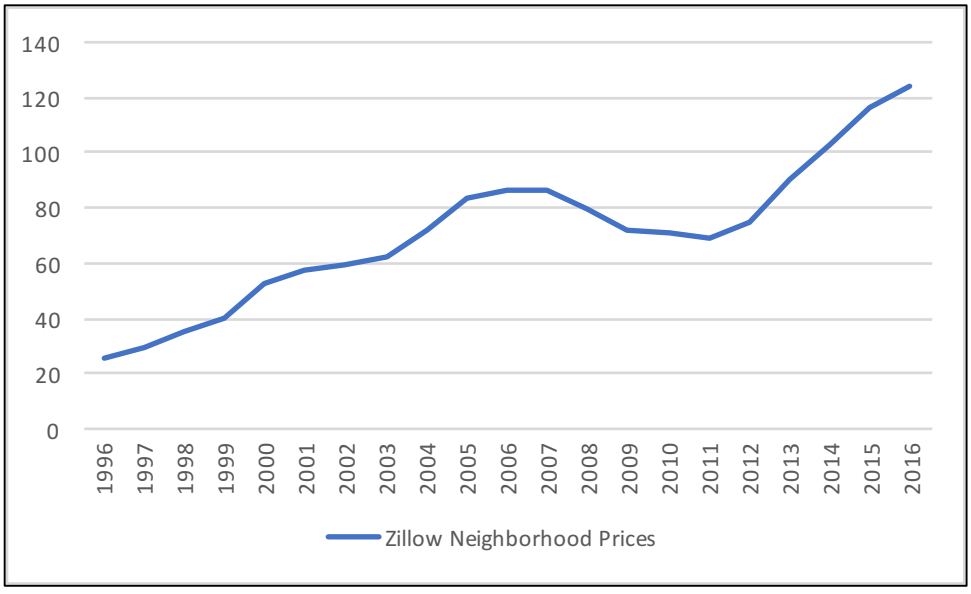


Figure 4: Evolution of GDP Deflator

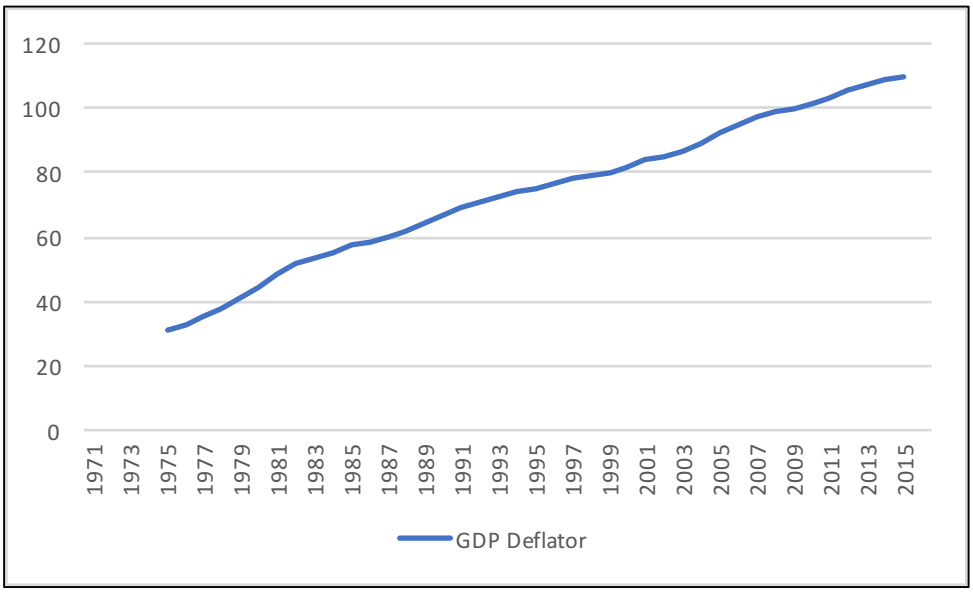
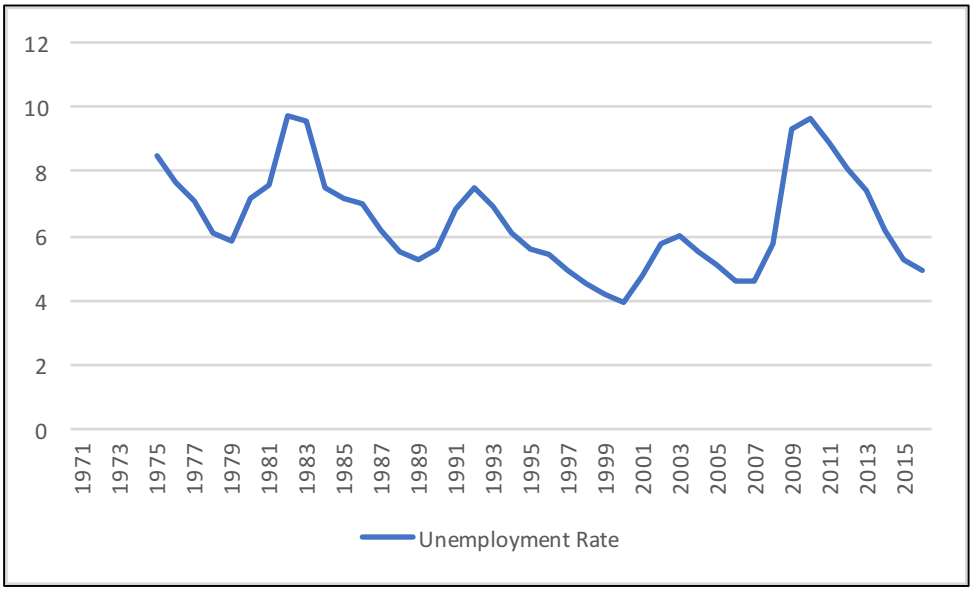


Figure 5: Evolution of Unemployment Rate



IV. Methodology

First, the Taylor rule will be recomputed[6] including housing prices to see how the federal funds rate responds to housing market conditions, thus addressing the potential problem of reverse causality between the federal funds rate and housing prices. That is, the Federal Reserve should respond to changes in inflation directly, changes in unemployment inversely, and changes in housing price inflation null[7]. Otherwise, the Federal Reserve would look at housing price inflation in determining the federal funds rate—the source of concern in this paper's model given the causal direction of federal funds rate to housing prices.

In the theoretically modified Taylor rule

$$ffr_t = \gamma_0 + \gamma_1 (\pi_t - \pi) + \gamma_2 (\mu_t - \mu) + \gamma_3 \pi(H_t) + \varepsilon_{it}$$

γ_1, γ_2, and γ_3 represent the relative weight given to reducing inflation (π_t) to the desired level (π), decreasing unemployment (μ_t) to the natural rate (μ), and managing housing price inflation ($\pi(H_t)$). The subscript t indexes the time period, specifically the quarter and year corresponding to the data point, and ε_{it} collects the unobserved errors that account for the difference between the predicted value and actual value of the federal funds rate.

From an operational point of view, the modified Taylor rule will be computed by the following ordinary least squares regression (OLS):

$$(1) \qquad ffr_t = \gamma_0 + \gamma_1 \, gdpDef_t + \gamma_2 \, uRate_t + \gamma_3 \, \pi(H_t) + \gamma_4 \, ffr_{t-1} + \varepsilon_{it}$$

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[6] Data on the Gross Domestic Product: Implicit Price Deflator (January 1975 – October 2015) and the Civilian Unemployment Rate (January 1975 – February 2016) from the Federal Reserve Bank of St. Louis will be utilized in recreating the Taylor rule, modified with housing price data from the Case-Shiller index.

[7] Note that inflation by construction incorporates housing price data such that the Federal Reserve already pays attention to changes in housing prices. However, attention paid to housing prices occurs insofar as they are also prices; attention paid to housing prices as a separate entity in the form of housing price inflation is the concern raised by possible reverse causality.

In recreating the Taylor rule, the GDP deflator ($gdpDef_t$) stands in for a measure of prices and the target inflation as does the unemployment rate ($uRate_t$) stand in for a measure of unemployment and its natural rate. The federal funds rate (int_t), the dependent variable, is also included in the regression as an independent variable lagged by a single time period—specifically, a quarter given the data—in order to deal with possible spurious correlation that arises with possibly trended data by removing unobserved effects that may correlate variables although no actual relationship exists. Note that this will be repeated in the paper's remaining regressions in order to deal with other such instances of this problem.

Inference testing will be conducted in order to determine whether γ_1, γ_2, and γ_3 are significant. If the first two coefficients are significant and the third insignificant, then the paper will have confirmed that the Federal Reserve responds to changes in prices directly, changes in unemployment inversely, and changes in housing price inflation null. Otherwise, if the third coefficient is significant, then a reverse causality exists and thus renders the assumption that the federal funds rate affects housing prices incorrect.

Another potential instance of reverse causality exists in the OLS regression of housing prices on the mortgage rate. Banks may observe changes in housing prices and then set their mortgage rates accordingly, meaning that the mortgage rate may respond to changes in housing prices. To account for this possibility, the method of instrumental variables will be employed with an instrument that correlates with the explanatory variable of mortgage rates. In the first stage, the mortgage rate will be regressed via OLS on the federal funds rate,[8] which will serve as

[8] Although the Federal Open Market Committee (FOMC) considers inflation in setting the federal funds rates, it cannot be said that the FOMC singularly considers housing prices—a potential reverse causality for the federal funds rate and housing prices—since changes in prices are examined via a basket of goods and services. Thus, this paper assumes only one possible direction of causality between housing prices and the federal funds rate, a result of not only

the instrument, in addition to the unemployment rate and GDP deflator in order to address any noise that might be explained by the state of the economy:

$$(2a) \quad mort_t = \alpha_0 + \alpha_1\, ffr_t + \alpha_2\, gdpDef_t + \alpha_3\, uRate_t + \alpha_4\, mort_{t-1} + \mu_t.$$

Here, α_1 represents the predicted change in the mortgage rate ($mort_t$) given a one-unit change in the federal funds rate; α_2 represents the predicted change in the mortgage rate given a one-unit change in the GDP deflator; and α_3 represents the predicted change in the mortgage rate given a one-unit change in the unemployment rate.

In the second stage, housing prices will be regressed via OLS on the mortgage rate once again but with the predicted values of the mortgage rate from the first stage used as the values of the mortgage rate as the independent variable:

$$(2b) \quad H_t = \beta_0 + \beta_1\, mort_t + \beta_2\, gdpDef_t + \beta_3\, uRate_t + \beta_4\, H_{j,t-1} + \varepsilon_{it}.$$

Here, β_1 represents the predicted change in housing prices given a one-unit change in the mortgage rate; β_2 represents the predicted change in housing prices given a one-unit change in the GDP deflator; and β_3 represents the predicted change in housing prices given a one-unit change in the unemployment rate. As before, inference testing regarding the significance of the coefficients will determine whether or not a reverse causality exists.

After having addressed the two possible instances of reverse causality, housing prices will be regressed via ordinary least squares (OLS) on the federal funds rate among the other independent variables:

$$(3) \quad H_{j,t} = \beta_0 + \beta_1\, ffr_t + \beta_2\, gdpDef_t + \beta_3\, uRate_t + \beta_4\, H_{j,t-1} + \beta_5\, t + \varepsilon_{it}$$

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making sense of the economic explanation but also satisfying the conditions necessary for the method of instrumental variables.

In this method, β_1 represents the predicted change in housing prices given a one-unit change in the federal funds rate; β_2 represents the predicted change in housing prices given a one-unit change in the GDP deflator; and β_3 represents the predicted change in housing prices given a one-unit change in the unemployment rate. The time variable t is also included in the regression as an independent variable in order to deal with any additional spurious correlation that may arise from trended time series data. Note that this will be repeated in the paper's remaining regressions when relevant in order to deal with other such instances of this problem. The variable ε_{it} collects the unobserved errors that account for the difference between the predicted value and actual value of housing prices, and the new subscript j for H_{jt} indexes the geographic location of the housing price data, either nationally or regionally with San Francisco.

Similarly, housing prices will also be regressed via OLS on the mortgage rate and the other independent variables:

$$(4) \qquad H_{j,t} = \beta_0 + \beta_1 \, mort_{j,t} + \beta_2 \, gdpDef_t + \beta_3 \, uRate_t + \beta_4 \, H_{j,t-1} + \beta_5 \, t + \varepsilon_{it}$$

Since mortgage data will be employed from the Freddie Mac survey, β_1 then represents the predicted change in housing prices given a one-unit change in the mortgage rate; β_2 represents the predicted change in housing prices given a one-unit change in the GDP deflator; and β_3 represents the predicted change in housing prices given a one-unit change in the unemployment rate. The new subscript j for $mort_{jt}$ indexes the geographic location of the mortgage rate, either nationally or regionally with the West[9]. Otherwise, all other notation and indexing remain the same and that regressions will be repeated with the different housing price data—once at the

[9] Recall that Freddie Mac's Primary Mortgage Market Survey has regional mortgage rate data, in addition to its primary mortgage rate, for the Northeast, Southeast, Northcentral, Southwest, and West, the latter of which will be employed to best capture the housing market in California and the San Francisco Bay Area.

national level and again for San Francisco. In both sets of the OLS regressions, inference testing will be conducted to determine whether the coefficients are significant and thus indicate a possible causal relationship in the data.

As the market may respond with delays to changes in the interest rate, another OLS regression of housing prices on the federal funds rate will be conducted to account for time lags, which captures the dynamic of the market equilibrium. The regression will take the form

$$(5) \qquad H_{j,t} = \beta_0 + \beta_1 \, ffr_{-1} + \beta_2 \, ffr_{-2} + \beta_3 \, ffr_{-3} + \beta_4 \, ffr_{-4} + \ldots + \varepsilon_{it}$$

For integer values of $k \in (0, 5)$, β_k represents the predicted change in housing prices given a one-unit change in the federal funds rate for the specific time period t (ffr_t) and thus captures the potential effect of the lag between setting the federal funds rate and affecting housing prices[10]. The other independent variables—the GDP deflator, the unemployment rate, and the lagged instance of the dependent variable—will also be included in the regression with the same number of lags. Otherwise, notation, indexing, and data sources remain the same as before, and the regression will also be applied in the case of housing prices on the mortgage rate.

Given the seasonal nature of the housing market and that the data is at the quarterly level, some fixed effects must be considered in order to examine if housing prices are influenced by activity more so during certain times of the year. For example, intuition would lead the paper to expect greater housing market activity in the third quarter of any given year – July, August, and September – because of the warmer weather conditions, summer vacation for children, and subsequent greater likelihood of families to relocate.

[10] The choice of lagging the federal funds rate up to four time periods occurs because each time period represents a quarter within a given year such that the lagged federal funds rate variables may capture activity from four quarters (i.e., one year) from the initial time period of interest.

As such, housing prices will be regressed on the federal funds rate, the other usual independent variables, and dummy variables for the different quarters in any given calendar year:

$$(6) \qquad H_{j,t} = \beta_0 + \beta_1 ffr_t + \beta_2 gdpDef_t + \beta_3 uRate_t + \beta_4 q_1 + \beta_4 q_2 + \beta_5 q_3 + \beta_6 H_{j,t-1} + \varepsilon_{it}$$

In this method, β_1 represents the predicted change in housing prices given a one-unit change in the federal funds rate; β_2 represents the predicted change in housing prices given a one-unit change in the GDP deflator; β_3 represents the predicted change in housing prices given a one-unit change in the unemployment rate; and β_4, β_5, and β_6 represent the predicted change in housing prices given the quarterly value, capturing the fixed effects of a single quarter upon the dependent variable of housing prices. Note that the error term, by construction, picks up the fixed effects relating to the fourth quarter since it has no dummy variable of its own.

Finally, housing prices from Zillow's neighborhood data for the San Francisco Bay Area will be regressed on the regional mortgage rate and the other usual independent variables in addition to the distance of any given neighborhood from downtown San Francisco and the interaction of the regional mortgage rate and the distance from downtown:

$$(7) \qquad H_{jt} = \beta_0 + \beta_1 mort_t + \beta_2 gdpDef_t + \beta_3 uRate_t + \beta_4 H_{jt-1} + \beta_5 t + \beta_6 dist_j + \beta_7 mort_t\, dist_j + \varepsilon_{it}$$

In this method, β_1 represents the predicted change in housing prices given a one-unit change in the mortgage rate; β_2 represents the predicted change in housing prices given a one-unit change in the GDP deflator; β_3 represents the predicted change in housing prices given a one-unit change in the unemployment rate; β_6 represents the predicted change in housing prices given a one-unit change in the distance from downtown San Francisco; and β_7 represents the predicted change in housing prices given a one-unit change in the interaction term of the mortgage rate and distance from downtown. The latter two coefficients are of interest to the paper insofar as their results confirm economic intuition regarding the relationship between housing prices and distance from

the downtown area of a city and how any given neighborhood's distance from downtown may augment or diminish the influence of the mortgage rate on housing prices.

V. Results

There are several points of interest to note from the recomputed Taylor rule (Figure 6). With or without housing price inflation included as an independent variable, the regression confirms that the Federal Reserve responds inversely to changes in unemployment; without housing price inflation, the coefficient is negative and significant at the 0.01 level, and with housing price inflation, the coefficient is negative and significant at the 0.10. In the former case, the Federal Reserve does not directly respond to changes in prices as expected but instead exhibits a negative, significant coefficient – thus responding inversely – but in the latter case, the coefficient for the GDP deflator is not significant at any level. As such, the regression does not confirm that the Federal Reserve responds directly to changes in prices. Furthermore, the regression with housing price inflation found that the Federal Reserve does respond to changes in housing prices directly. That is, the resulting coefficient for housing price inflation is positive, significant at a level of 0.05, and rather large in magnitude compared to the other coefficients. Such a result not only raises concerns about the possibility of reverse causality—the Federal Reserve examining housing prices before setting the interest rate—but also questions the use of the federal funds rate as an instrument because the federal funds rate seems to move in response to changes in housing prices as opposed to influencing housing prices by means of the mortgage rate. Altogether, this last result from the recomputed Taylor rule may indicate a flaw in the model's assumptions and thus impact its analysis.

Figure 6: Recomputed Taylor rule with and without housing price inflation

VARIABLES	Federal Funds Rate	Federal Funds Rate
GDP Deflator	-0.898***	-0.509
	(0.286)	(0.341)
Unemployment Rate	-0.120***	-0.0843*
	(0.0454)	(0.0482)
Housing Price Inflation		44.44**
		(21.57)
Lagged Federal Funds Rate	0.929***	0.943***
	(0.0239)	(0.0247)
Constant	4.936***	-41.59*
	(1.416)	(22.63)
Observations	163	163
R-squared	0.953	0.954

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the first stage of the instrumental variable regression (Figure 7), the federal funds rate is significant at a level of at least 0.01, and consequently, the strong first stage indicates that the federal funds rate and mortgage rate move together. While this result does not necessarily alleviate any concerns about the model's assumptions and the possible case of reverse causality, the finding does confirm that the mortgage rate acts as a mechanism by which the federal funds rate and housing prices may interact. Based on the results from the recomputed Taylor rule, not much else can be said regarding the direction of causality between the federal funds rate and housing prices, only that the mortgage rate connects them regardless of the causal direction.

Figure 7: Instrumental variable – first stage regression

VARIABLES	Mortgage Rate
GDP Deflator	-0.104
	(0.130)
Unemployment Rate	0.0602**
	(0.0240)
Federal Funds Rate	0.207***
	(0.0219)
Lagged Mortgage Rate	0.747***
	(0.0274)
Constant	1.051
	(0.654)
Observations	164
R-squared	0.986

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the second stage of the instrumental variable regression (Figure 8), the mortgage rate has a negative coefficient that is significant at the 0.05 level, which lends confidence to the model's assumption that banks respond to changes to the federal funds rate by adjusting the mortgage rate and thus affecting housing prices inversely through consumer demand channels. Essentially, an increase in the mortgage rate by a single unit implies a decrease in national housing prices by the designated negative coefficient. In other words, higher mortgage rates make financing a home purchase expensive such that consumer demand falls, resulting in a decrease in prices.

Figure 8: Instrumental variable – second stage regression

VARIABLES	National Housing Prices
Predicted Mortgage Rate	-0.00138**
	(0.000558)
GDP Deflator	-0.0216
	(0.0169)
Unemployment Rate	-0.00317***
	(0.000820)
Lagged National Housing Prices	0.995***
	(0.0108)
Constant	0.159***
	(0.0323)
Observations	163
R-squared	0.999

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The next set of regressions test the main relationship of the model – how the federal funds rate influences national and regional housing prices (Figure 9). At the national level, the federal funds rate exhibits a negative, insignificant coefficient, moving in the right direction but without the predictive power that the paper expected. Both the GDP deflator and the unemployment rate move in the opposite directions as would be best understood by the model, and the coefficients for each are significant at the .05 level at least. Higher price levels would imply higher housing prices, and higher rates of unemployment would imply lower housing prices; however, neither is true with national housing prices as the dependent variable. In the case of San Francisco housing prices, the federal funds rate exhibits a positive, insignificant coefficient, moving in the wrong direction but at least without any predictive power in such

movement. Similar to the regression with national housing prices, the GDP deflator moves inversely with housing prices and not as expected, but the unemployment rate moves inversely with housing prices as expected, though without predictive power due to its insignificance. In terms of the main variable of interest, the federal funds rate, the results from the two regressions do not conflict with the model's assumptions too much. Nationally, the federal funds rate moves inversely with housing prices albeit without significance, and for San Francisco, the positive coefficient for the federal funds rate is neither significant in its p-value nor significant in interpretation given that the federal funds rate should have less of an impact and influence upon regional housing prices.

Figure 9: National and regional housing prices on federal funds rate

VARIABLES	National Housing Prices	San Francisco Housing Prices
Federal Funds Rate	-0.000256	0.00102
	(0.000558)	(0.00228)
GDP Deflator	-0.0389**	-1.149***
	(0.0187)	(0.177)
Unemployment Rate	-0.00390***	-0.00444
	(0.000847)	(0.00274)
Lagged National Housing Prices	0.986***	
	(0.0121)	
Time	0.000283*	0.00631***
	(0.000147)	(0.000929)
Lagged San Francisco Housing Prices		0.981***
		(0.0151)
Constant	0.239***	4.453***
	(0.0544)	(0.663)
Observations	163	115
R-squared	0.999	0.996

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Similar to the previous regressions, this set tests the relationship between the mortgage rate and national and regional housing prices (Figure 10). In the case of national housing prices, the coefficient for the mortgage rate is neither negative nor significant at any level, and the GDP deflator and unemployment rate both move in opposite directions to what is expected, with each coefficient significant with their p-values as well. Such results, as above in the case of the San Francisco housing prices regressed on the federal funds rate, are not overwhelming concerning since the relationship between federal funds rate and national housing prices and the relationship

between the mortgage rate and San Francisco (regional) housing prices are of greater concern to the model and its analyses. In the case of San Francisco housing prices, the mortgage rate—which here is regionally specific to the West to better capture any relationship—exhibits a negative and significant coefficient at the 0.05 level. Despite the GDP deflator and the unemployment rate moving in the opposite directions as expected and with significant coefficients at the lowest possible levels, the regression still has a strong result with the regional mortgage rate for the West having predictive power on San Francisco housing prices, affirming the model's basic assumptions about interest rates and housing prices.

Figure 10: National and regional housing prices on mortgage rate

VARIABLES	National	San Francisco Housing Prices
Mortgage Rate	0.000208	
	(0.000869)	
GDP Deflator	-0.0422**	-1.229***
	(0.0199)	(0.177)
Unemployment Rate	-0.00395***	-0.00607***
	(0.000902)	(0.00221)
Lagged National Housing Prices	0.984***	
	(0.0123)	
Time	0.000359**	0.00593***
	(0.000180)	(0.000897)
Mortgage Rate (West)		-0.0109**
		(0.00470)
Lagged San Francisco Housing Prices		0.989***
		(0.0152)
Constant	0.252***	4.899***
	(0.0597)	(0.675)
Observations	163	115
R-squared	0.999	0.996

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The next set of regressions repeat the above—housing prices on federal funds rate/mortgage rate (Figures 9 and 10)—but with time lags to see if any changes occur due to lags in the market responding to changes in interest rates[11]. In terms of national housing prices, the effect of the time lags is mixed. For the federal funds rate, three of the four lagged coefficients are negative, but none of them exhibit significance at any level; for the GDP deflator and the

[11] Note that these regression tables, due to their length, are included in the appendix section.

unemployment rate, two of the four are positive and three of the four are negative, respectively. The third-time lag, which represents a response in the relationship between variables three quarters later, has all the coefficients with their expected signs; otherwise, there seems to be no other pattern to the lags and their effect on the sign of the variables of interest. Without having significance for any of the coefficients for the third-time lag, the paper has difficulty in expressing any predictive power three quarters later, though the observation is interesting regardless. Moreover, most of the coefficients coincide with the model's expectations such that there is no real challenge about any of the assumptions made. In terms of San Francisco housing prices, the results are also mixed. Two of the four lags for the federal funds rate have negative signs; one of the four lags for the GDP deflator has a positive sign; and one of the four lags for the unemployment rate has a negative sign. Accordingly, deducing any meaningful results from the lags becomes challenging. In the case of housing prices regressed on the mortgage rate with lags, results are similarly mixed such that comments are not necessarily warranted in describing the details about the coefficients' signs and significance.

In addition to the time lags, dummy variables corresponding to four quarters in a year have been included in the base regressions of housing prices on interest rates to account for any fixed effects caused by the seasonal nature of the housing market (Figure 11). In terms of national housing prices, the federal funds rate has a negative and significant coefficient at the 0.05 level while the coefficients for the GDP deflator and unemployment rate are opposite in sign to their expected values. The dummy variable for the second and third quarter, however, are positive and significant at a level of 0.01, possibly implying that demand for housing between

the months of April and September is greater such that prices increase[12]. Intuitively, this fits with housing market activity given the various conditions in these quarters that are more conducive to purchasing housing and relocating. In terms of San Francisco housing prices, the signs for the federal funds rate, GDP deflator, and unemployment rate all match with the expected sign—that is, negative, positive, and negative (respectively)—though only the unemployment rate is significant at the 0.10 level while the others are not significant at any level. Additionally, none of the dummy variables for the quarters are significant. Replacing the federal funds rate with the mortgage rate[13] results in very similar outcomes for national housing prices, but in the case of San Francisco housing prices, doing so results in a coefficient for the mortgage rate that is negative and significant at the 0.01 level along with a negative and significant coefficient for the unemployment rate. Altogether, these results lend confidence to the model's assumptions about the inverse relationship between the federal funds rate / mortgage rate with housing prices with the quarterly effects indicating a greater seasonal impact nationally than in San Francisco, understandable given the competitive housing market and feasibility of moving any time of the year without weather constraints.

[12] Generally, predictability with asset prices and interest rates generates arbitrage opportunities such that there are little to no fixed effects present. However, the housing market may not follow this phenomenon as much for the following reasons: there does exist a sizeable cost to buying and selling properties; liquidity constraints prevent the borrowing of substantial funds to purchase multiple properties; and strong disincentives and barriers exist that make moving during non-optimal quarters difficult or infeasible.

[13] Note that this regression table is included in the appendix section.

Figure 11: National and regional housing prices on federal funds rate – quarterly effects

VARIABLES	National Housing Prices	San Francisco Housing Prices
Federal Funds Rate	-0.000915**	-0.00213
	(0.000387)	(0.00269)
GDP Deflator	-0.0259*	0.0105
	(0.0152)	(0.0574)
Unemployment Rate	-0.00366***	-0.00647*
	(0.000751)	(0.00328)
q1	0.000785	-0.000485
	(0.00305)	(0.00914)
q2	0.0162***	-0.000190
	(0.00304)	(0.00907)
q3	0.0129***	-0.000874
	(0.00303)	(0.00907)
Lagged National Housing Prices	0.999***	
	(0.00955)	
Lagged San Francisco Housing Prices		0.981***
		(0.0182)
Constant	0.149***	0.102
	(0.0292)	(0.204)
Observations	163	115
R-squared	0.999	0.994

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The penultimate set of regressions bisect the data set to values before and after 2006—when the housing crisis occurred—to capture any effect due to the unusual state of the economy and monetary policy (Figure 12). For the recomputed Taylor rule without housing price inflation, the regression with pre-crisis values results in similar outcomes: both the GDP deflator and the unemployment rate exhibit negative, significant coefficients. However, the regression with post-

crisis values deviates from the common results in that it does not have significant coefficients, perhaps a result of the lack of predictive power during such a tumultuous and erratic time economically. For the recomputed Taylor rule with housing price inflation, the greatest point of interest concerns the positive and rather large coefficient for housing price inflation. The regression with pre-crisis values exhibits these features but is not significant at any level; the regression with post-crisis values exhibits these features and is significant at the 0.01 level.

Among all other results, this alleviates some pressure regarding the problems with the model's assumption about causality and the possible case of reverse causality discussed earlier. It appears that the Federal Reserve paid no special attention to housing prices prior to the recession, instead observing them along with all other prices, but during and after the recession because of the speculation and bubble that occurred, the Federal Reserve paid significant attention to housing prices such that it influenced the setting of the federal funds rate. Accordingly, the model's assumptions about the causal direction between the federal funds rate and housing prices seems more reputable than before with any anomalies partially explained by the unusual state of the economy during and after the recession.

Figure 12: Recomputed Taylor rule with and without housing price inflation – pre and post housing crisis

VARIABLES	Federal Funds Rate Pre	Federal Funds Rate Post	Federal Funds Rate Pre	Federal Funds Rate Post
GDP Deflator	-1.215***	-4.893	-0.825*	-6.402*
	(0.386)	(3.985)	(0.492)	(3.460)
Unemployment Rate	-0.237***	-0.107	-0.189**	-0.0864
	(0.0773)	(0.0878)	(0.0859)	(0.0759)
Housing Price Inflation			47.66	44.51***
			(37.31)	(12.15)
Lagged Federal Funds Rate	0.949***	0.805***	0.961***	0.816***
	(0.0290)	(0.129)	(0.0303)	(0.111)
Constant	6.830***	23.58	-43.01	-14.10
	(1.936)	(19.15)	(39.06)	(19.45)
Observations	123	40	123	40
R-squared	0.928	0.966	0.929	0.975

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The following regressions involve the relationship between housing prices and interest rates before and after the housing crisis and recession (Figure 13). Examining the federal funds rate and national housing prices, the coefficient for the federal funds rate before the crisis is negative and insignificant and after the crisis is positive and insignificant. These results are not incredibly concerning for the model's assumption in that the former at least has the same sign as expected while the latter's deviation can be understood in the context of the crisis and the unusual state of the economy. Examining the mortgage rate and national housing prices, the coefficient for the mortgage rate before and after the crisis is positive and insignificant, contradicting the model's assumptions but at least without any predicative power. As previously mentioned, not having the expected relationship between national housing prices and the mortgage is somewhat palatable insofar as the model has greater interest in establishing

connections between national housing prices and the federal funds rate in addition to regional housing prices and the mortgage rate. Replacing national housing prices with San Francisco housing prices[14] results in similarly mixed outcomes. For example, the pre-crisis regional mortgage rate coefficient is positive and insignificant, and the post-crisis regional mortgage rate coefficient is negative and significant; the federal funds rate coefficient remains positive in both periods but is significant post-crisis.

Figure 13: National housing prices on federal funds rate / mortgage rate – pre and post housing crisis

VARIABLES	National Housing Prices Pre	National Housing Prices Post	National Housing Prices Pre	National Housing Prices Post
Mortgage Rate	0.000347	0.0139		
	(0.000556)	(0.0127)		
GDP Deflator	-0.119***	-2.288***	-0.114***	-1.495*
	(0.0140)	(0.798)	(0.0132)	(0.798)
Unemployment Rate	-0.00253***	-0.0163***	-0.00254***	-0.00692
	(0.000784)	(0.00499)	(0.000811)	(0.00662)
Lagged National Housing Prices	1.047***	0.650***	1.050***	0.770***
	(0.0103)	(0.123)	(0.0103)	(0.0944)
Time	0.000316*	0.0104***	0.000201	0.00754**
	(0.000165)	(0.00352)	(0.000156)	(0.00296)
Federal Funds Rate			-0.000135	0.00968
			(0.000369)	(0.00605)
Constant	0.299***	10.75***	0.276***	6.918*
	(0.0433)	(3.470)	(0.0397)	(3.489)
Observations	123	40	123	40
R-squared	1.000	0.965	1.000	0.967

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[14] Note that this regression table is included in the appendix section.

The final set of regressions utilizes the Zillow neighborhood prices to examine the relationship between local housing prices and the regional mortgage rate along with exploring how distance from a downtown metro area affects housing prices (Figure 14). Unfortunately, the Zillow neighborhood prices and the regional mortgage rate exhibit a direct, significant relationship at the 0.01 level. Bisecting the data set as before and re-running the regression results in the same outcome of a positive, very significant coefficient for the mortgage rate. This is particularly confusing given the model's assumption regarding the alleged inverse relationship between the two variables, not to mention that the most specified data for housing prices and the mortgage rate were employed in the analysis—Zillow neighborhood prices and the regional mortgage rate for the West. Without dividing the data set, the rest of the regression results follow the model's assumptions and economic intuition: prices move directly with housing prices, unemployment moves inversely with housing prices, and distance from the downtown area moves inversely with housing prices (i.e., moving one mile away from the downtown area decreased housing prices by the given coefficient for distance). While the interaction term mirrors the mortgage rate with its sign opposite to what was expected, the basic logic holds in that changing the distance from the downtown area not only explicitly moves with housing prices but also implicitly moves with housing prices by means of the mortgage rate, given that rates will differ depending upon the location of housing and its distance from the downtown area.

Figure 14: Zillow neighborhood prices on mortgage – pre and post housing crisis

VARIABLES	Zillow Neighborhood Prices	Zillow Neighborhood Prices Pre	Zillow Neighborhood Prices Post
Mortgage Rate (West)	0.0220**	0.0457***	0.107***
	(0.00984)	(0.0122)	(0.0185)
GDP Deflator	3.492***	-1.801**	-12.19***
	(0.410)	(0.779)	(1.328)
Unemployment Rate	-0.0761***	-0.0239**	-0.0699***
	(0.00347)	(0.0102)	(0.00453)
Lagged Zillow Neighborhood Prices	0.114***	0.0483***	0.0492***
	(0.00623)	(0.00902)	(0.00864)
Time	-6.04e-06	0.000159***	0.000226***
	(8.57e-06)	(1.47e-05)	(2.05e-05)
Distance from Downtown	-0.252***	-0.212***	-0.285***
	(0.00429)	(0.00548)	(0.00622)
Interaction	3.78e-05***	2.52e-05***	5.47e-05***
	(2.61e-06)	(2.87e-06)	(4.63e-06)
Constant	-2.990*	19.89***	66.37***
	(1.733)	(3.376)	(5.845)
Observations	21,466	10,506	10,960
R-squared	0.326	0.394	0.231

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VI. Conclusion

Working through the various regressions, the model seems to hold in terms of its direction and casual assumptions with some qualifications. For example, the recomputed Taylor rule with housing prince inflation indicates that the Federal Reserve does respond to changes in housing prices such that the causality assumed in the model may not hold. However, upon bisecting the data set to values before and after the housing crisis and recession, the results differ insofar as the Federal Reserve does not respond before but does respond after. The interpretation

here is that the Federal Reserve does not normally respond to housing prices specifically and instead considers them along with all other measurable prices, but due to the unusual state of the economy concerning the housing market, the Federal Reserve begins to respond to housing prices specifically once the crisis occurred. This finding does not contradict the model's expected outcomes but does qualify them with the nuance of time and corresponding economic conditions. However, having a sizeable time period in which the Federal Reserve does not respond to changes in housing prices inspires confidence for the results of the instrumental variable regression, which shows that the mortgage rate moves with the federal funds rate and then affects housing prices, because the previous result that the Federal Reserve examines housing prices and then sets the federal funds rate undermines the instrumental variable regression.

The various regressions of housing prices—national or regional with San Francisco—on interest rates—the federal funds rate or the mortgage rate—exhibit mixed results. On one hand, most of the regressions establish that there is a negative relationship between national housing prices and the federal funds rate in addition to regional housing prices and the mortgage rate. Switching the interest rates, though, does not result in the outcome: some coefficients are negative in value but not significant while others are positive and significant or not significant. On the other hand, the relationship between the GDP deflator and the unemployment rate with housing prices is far less clear. These independent variables are included in the various regression because (a) economic intuition leads the paper to expect certain relationships—positive and negative, respectively—and (b) these variables may pick up any background noise due to the state of the economy that would otherwise influence the relationship between housing prices and interest rates.

Tweaking the regressions by adding lags, considering quarterly effects, and bisecting the data set all resulted in different combinations of signs for the coefficients and varying degrees of significance. In the case of time lags, the results did not offer anything of great interest. The third-time lag used in regressing national housing prices on the federal funds rate had coefficients for the independent variables consistent with the model's expectations, but the none of the values were significant at any level, preventing the paper from making any conclusions about the predictive power there. In the case of quarterly effects, the results show that national housing prices exhibit seasonality during the second and third quarters with greater prices during those time periods—explained by better weather conditions, the end of the school year, and so forth—while regional housing prices in San Francisco exhibit no such differences, perhaps a result of the more consistent weather and competitive housing market. In the case of re-running the regressions with the data set bisected by the housing crisis, not much of interest results other than the discrepancy in the Federal Reserve setting the federal funds rate that then affects housing prices—before the crisis—and examining changes in housing prices before setting the federal funds rate—after the crisis.

Much of the model—with exception of the regressions with lags—depends upon changes occurring because of changes in demand. Some work may be done in the future to address the supply side and how banks might influence housing prices themselves as opposed to moving in response to the federal funds rate. Connecting the Treasury bill to the federal funds rate and the mortgage right might be of value in that regard.

Appendix

Figure 15: National and regional housing prices on federal funds rate with lags

VARIABLES	National Housing Prices	San Francisco Housing Prices
Lagged Federal Funds Rate	-0.000580	0.0101*
	(0.000833)	(0.00558)
Lagged GDP Deflator	-0.137	-0.528
	(0.284)	(1.106)
Lagged Unemployment Rate	-0.00252	0.00943
	(0.00304)	(0.00936)
Lagged National Housing Prices	1.897***	
	(0.0508)	
Lagged Federal Funds Rate (2)	0.000767	-0.0180*
	(0.00110)	(0.00952)
Lagged GDP Deflator (2)	0.114	2.234
	(0.489)	(1.587)
Lagged Unemployment Rate (2)	0.00839*	0.0114
	(0.00505)	(0.0155)
Lagged National Housing Prices (2)	-1.700***	
	(0.0970)	
Lagged Federal Funds Rate (3)	-0.000541	0.00317
	(0.00110)	(0.00940)
Lagged GDP Deflator (3)	0.105	-0.467
	(0.485)	(1.555)
Lagged Unemployment Rate (3)	-0.00281	-0.0312**
	(0.00495)	(0.0154)
Lagged National Housing Prices (3)	1.623***	
	(0.0981)	
Lagged Federal Funds Rate (4)	-0.000638	-0.00113
	(0.000791)	(0.00540)
Lagged GDP Deflator (4)	-0.0607	-1.177
	(0.285)	(0.989)
Lagged Unemployment	-0.00283	0.00437

Rate (4)		
	(0.00277)	(0.0102)
Lagged National Housing Prices (4)	-0.841***	
	(0.0529)	
Lagged San Francisco Housing Prices		1.876***
		(0.105)
Lagged San Francisco Housing Prices (2)		-1.010***
		(0.224)
Lagged San Francisco Housing Prices (3)		0.210
		(0.223)
Lagged San Francisco Housing Prices (4)		-0.121
		(0.106)
Constant	0.00717	-0.0132
	(0.0253)	(0.133)
Observations	161	113
R-squared	1.000	0.999

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 16: National and regional housing prices on mortgage rate with lag

VARIABLES	National Housing Prices	San Francisco Housing Prices
Lagged Mortgage Rate	-0.00171	
	(0.00142)	
Lagged GDP Deflator	-0.0794	0.178
	(0.292)	(1.164)
Lagged Unemployment Rate	-0.00149	0.00616
	(0.00297)	(0.0102)
Lagged National Housing Prices	1.902***	
	(0.0516)	
Lagged Mortgage Rate (2)	-7.83e-05	
	(0.00213)	
Lagged GDP Deflator (2)	0.0450	1.764
	(0.502)	(1.680)
Lagged Unemployment Rate (2)	0.00631	0.0195
	(0.00507)	(0.0173)
Lagged National Housing Prices (2)	-1.689***	
	(0.0994)	
Lagged Mortgage Rate (3)	-0.000322	
	(0.00215)	
Lagged GDP Deflator (3)	0.0897	-1.176
	(0.494)	(1.614)
Lagged Unemployment Rate (3)	-0.00312	-0.0284*
	(0.00491)	(0.0167)
Lagged National Housing Prices (3)	1.610***	
	(0.0999)	
Lagged Mortgage Rate (4)	0.00109	
	(0.00144)	
Lagged GDP Deflator (4)	-0.0361	-0.830
	(0.280)	(0.983)
Lagged Unemployment Rate (4)	-0.00108	-0.000904
	(0.00271)	(0.0108)
Lagged National Housing	-0.841***	

Prices (4)		
	(0.0537)	
Lagged Mortgage Rate (West)		-0.00719
		(0.00569)
Lagged San Francisco Housing Prices		1.971***
		(0.101)
Lagged Mortgage Rate (West) (2)		0.000231
		(0.00779)
Lagged San Francisco Housing Prices (2)		-1.216***
		(0.223)
Lagged Mortgage Rate (West) (3)		0.000826
		(0.00755)
Lagged San Francisco Housing Prices (3)		0.317
		(0.226)
Lagged Mortgage Rate (West) (4)		-0.0102*
		(0.00533)
Lagged San Francisco Housing Prices (4)		-0.111
		(0.106)
Constant	0.00617	0.584**
	(0.0260)	(0.228)
Observations	161	113
R-squared	1.000	0.999

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 17: National and regional housing prices on mortgage rate – quarterly effects

VARIABLES	National Housing Prices	San Francisco Housing Prices
Mortgage Rate	-0.00116**	
	(0.000494)	
GDP Deflator	-0.0231	-0.163*
	(0.0151)	(0.0858)
Unemployment Rate	-0.00320***	-0.00631**
	(0.000734)	(0.00264)
q1	0.000708	-0.000665
	(0.00305)	(0.00886)
q2	0.0162***	0.00147
	(0.00304)	(0.00881)
q3	0.0130***	0.000224
	(0.00303)	(0.00879)
Lagged National Mortgage Rate	0.997***	
	(0.00965)	
(West)		-0.0154***
		(0.00558)
Lagged San Francisco Housing Prices		0.994***
		(0.0182)
Constant	0.147***	0.912**
	(0.0288)	(0.361)
Observations	163	115
R-squared	0.999	0.995

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 18: Regional housing prices on federal funds rate / mortgage rate – pre and post housing crisis

VARIABLES	San Francisco Housing Prices Pre	San Francisco Housing Prices Post	San Francisco Housing Prices Pre	San Francisco Housing Prices Post
GDP Deflator	-0.668***	-3.654**	-0.842***	-4.519***
	(0.156)	(1.621)	(0.198)	(1.212)
Unemployment Rate	-0.00967**	0.00559	-0.000681	0.00823
	(0.00376)	(0.0121)	(0.00845)	(0.00968)
Lagged National Housing Prices				
Time	0.00395***	0.0138*	0.00537***	0.0245***
	(0.00109)	(0.00733)	(0.00163)	(0.00493)
Federal Funds Rate			0.00541	0.0376***
			(0.00397)	(0.00824)
Mortgage Rate (West)	0.00362	-0.0360*		
	(0.00481)	(0.0184)		
Lagged San Francisco Housing Prices	1.001***	1.098***	0.990***	0.852***
	(0.0169)	(0.122)	(0.0193)	(0.0876)
Constant	2.530***	14.36**	3.139***	17.67***
	(0.603)	(6.842)	(0.713)	(5.161)
Observations	75	40	75	40
R-squared	0.998	0.980	0.998	0.986

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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