Fair Market Rents Trend Component Modeling Technical Report

Alternative Methods for Calculating Fair Market Rents in Rental Markets with Rapidly Rising Rents

U.S. Department of Housing and Urban Development | Office of Policy Development and Research

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and Terner Center

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Executive Summary

The U.S. Department of Housing and Urban Development (HUD) estimates Fair Market Rents (FMRs) to inform reimbursement rates for federal housing assistance programs. FMRs are calculated for more than 600 metropolitan areas and 2,000 non-metropolitan areas. FMRs consist of base rent derived from the American Community Survey (ACS), an inflation factor that is used to bring base values to current values, and a trend factor (forecast) that is used to bring current values to future values. (The expected change in the gross rent index divided by the current gross rent index is calculated as the trend factor.)

The gross rent index consists of two components. The Rent of Primary Residence and the Fuels and Utilities Consumer Price Index (CPI) factors are modeled using time series econometric approaches to forecast seven quarters into the future. HUD has investigated alternative approaches to developing the trend component models.

In addition, HUD has recognized that rapidly rising rents introduce further challenges to the calculation and application of FMRs and the possibility of increased discrepancies between FMRs and the ability of households to gain access to affordable housing. This research builds upon earlier work done.

UrbanSim Inc. and the Terner Center have introduced a multivariate, cointegration approach to modeling the FMR trend factor components and taken a statistical approach to define markets that may be experiencing rapidly rising rents. The multivariate time series approach to modeling both the rent and the fuel and utilities components of the CPI have promising in-sample forecasting results and introduce an additional layer of economic theory into the existing methodology. Identifying areas with rapidly rising rents is inherently a difficult problem but using a set of data-driven statistical methods—including band-pass filters, cointegration, and rent ratios—and alternative rent data sources—such as Apartment List—has helped pinpoint periods when rents have risen rapidly and outpaced their fundamentals. Decomposing rents into both long-run trends and cyclical components using band-pass filters is a promising approach to identifying where rising rents have historically occurred but also could help identify areas where rents are rising rapidly in real time.

Introduction

HUD must forecast Fair Market Rents (FMRs) several quarters in advance because of the lag between when rents are updated and when HUD needs the FMR values reset. HUD's current methodology for updating FMR is to use a trend factor that is applied to each metropolitan area in the United States. The trend factor models are specified using an ARIMA(X) time series approach. Producing more accurate trend forecasts is increasingly important in the current market environment, in which numerous geographies have experienced rapidly rising rents throughout the past business cycle, and COVID-19-related economic impacts may have had exceptional and unexpected consequences on local rental markets. This report will summarize the theory and preliminary results to updating the Rent of Primary Residence Consumer Price Index (CPI) component and the Fuels and Utilities CPI component and will introduce a statistical approach to helping identify markets with rapidly rising rents.

Alternative Calculations to Account for Areas with Rapidly Rising Rents

Variables

Dependent Variables

The dependent variables modeled include the Rent of Primary Residence Consumer Price Index (CPI) and the Fuels and Utilities CPI. Both variables originated from the Bureau of Labor Statistics (BLS). The Rent CPI is based on a repeat survey of rental housing units. Adjustments for age and vacancies are made to the series over time. The geographic coverage for each CPI component included Alaska, Atlanta, Chicago, Baltimore, Boston, Dallas, Denver, Detroit, Honolulu, Houston, Los Angeles, Miami, Minneapolis, New York/New Jersey, Philadelphia, Phoenix, San Francisco, San Diego, Seattle, St. Louis, Tampa, and Washington, D.C. There was no attempt to seasonally adjust the price series before estimation and forecast evaluation.

Additional Variables

The econometric approach originally proposed by UrbanSim and the Terner Center was a multivariate vector autoregression (VAR) and extensions to that model that included cointegrating vectors (vector error correction model [VECM]). The approach would be used for both the Rent and Fuel CPI components. These models would be extensions to both autoregressive integrated moving average (ARIMA) models and prior research projects that included additional exogenous variables acting as structural drivers of both components. VAR models are extensions of ARIMA models, in which every variable is regressed on the same number of lags of itself and lags of each variable included in the specification. All variables are treated endogenously. Variable selection for each CPI component was based on the economic theory of underlying supply and demand driver for each variable. A subset of those variables was used for final specifications.

Rent of Primary Residence CPI Model Variables

Variables for inclusion in the Rent CPI model included housing variables such as Federal Housing Finance Agency (FHFA) home price indices, inventory, and housing permits. Demographic variables included population and number of households. Employment variables included labor force, nonfarm payrolls, and employment counts from the Quarterly Census of Employment and Wages. Per capita personal income was used as an overall proxy for income measures. Those variables represent common supply and demand drivers that align with economic and real estate theory and are used in many applied forecasting models. In addition, when developing error-correction models, one is looking for variables that may share long-run equilibrium relationships, such as prices and income or rents and prices. Variables are listed in exhibit 1.

Exhibit 1. Rent CPI Variables

Variable	Source	Periodicity	Geography	Purpose
House Price Index	FHFA	Monthly	MSA	Proxy for price
Unemployment Rate	BLS	Monthly	MSA	Proxy for labor market slack
Nonfarm Payrolls	BLS	Monthly	MSA	Proxy for labor market
Population	Census	Annual	MSA	Proxy for demographics
Labor Force	BLS	Monthly	MSA	Proxy for labor for dynamics
Personal Income per Capita	BEA	Annual	MSA	Proxy for income dynamics
Housing Inventory	Realtor.com	Monthly	CBSA	Proxy for housing inventory
Mortgage Rates	Freddie Mac	Weekly	National	Proxy for financing costs
Housing Permits	Census	Monthly	MSA	Proxy for building activity

BEA = Bureau of Economic Analysis. BLS = Bureau of Labor Statistics. CBSA = core-based statistical area. FHFA = Federal Housing Finance Agency. MSA = metropolitan statistical area.

Fuel and Utility CPI Model Variables

Variables for inclusion in the Fuel CPI component included West Texas Intermediate (WTI) crude oil prices, natural gas prices, electricity prices, and the U.S. Producer Price Index (PPI). Including energy prices with the Fuel CPI was an attempt to capture underlying drivers of the Fuel CPI, similar to modeling oil prices with gasoline and jet fuel, as done when estimating the crack spread in energy trading. The motivation lies in the derived demand that may exist in the underlying input prices. In addition, the PPI could be tested separately as an overall raw material proxy. Literature that modeled the CPI and PPI as a VAR tested the theory of cost push versus demand pull inflation (Baumeister, Kilian, and Zhou, 2017). Said differently, do consumer prices drive producer prices or vice versa—or both? Exhibit 2 lists the variables.

Exhibit 2. Fuel CPI Variables

Variable	Source	Periodicity	Geography	Purpose
WTI Crude Price	EIA	Monthly	NA	Oil Price
Henry Hub Natural Gas	EIA	Monthly	NA	Natural Gas
U.S. Average Electricity Price	EIA	Monthly	NA	Electricity Price

EIA = U.S. Energy Information Administration. NA = not applicable. WTI = West Texas Intermediate.

Econometric Methodology

The proposed econometric methodology builds upon prior research by introducing a multivariate time series approach to forecasting both CPI series. This approach can be used to measure whether a local multivariate approach outperforms the current ARIMA forecasting approach. VAR models are widely used in macroeconomic forecasting and have demonstrated forecasting performance in short- to medium-term horizons (Sims, 1980). As an example, suppose one was interested in forecasting both inflation and employment for a given metropolitan statistical area (MSA). The inflation equation would be a function of the same number of lags of both inflation and employment, and a symmetric equation would be estimated for employment. VAR models can be generalized to more than two variables.

- VAR models are transparent in methodology and rely on well-known estimation methods, such as ordinary least squares and maximum likelihood; more complicated systems estimators are unnecessary.
- All variables are treated endogenously, eliminating the need for producing exogenous forecasts for independent variables in a traditional structural approach, thus reducing the risk of bias in variable selection. Often, this method also better represents the true relationship between variables.
- The interaction of variables in VAR models may better represent local economic conditions through both supply and demand variables rather than relying on ARIMA models, as was done in prior research.
- VARs can be augmented with error-correction terms, which introduce a statistical long-run relationship into the model that can act as an equilibrium adjustment term.

The theory of cointegration has been a widely used econometric technique in developing real estate models. *Cointegration* is defined as two or more variables sharing a statistical, long-run relationship. More specifically, cointegration allows for two variables to vary over the short run but requires a long-run equilibrium relationship to be maintained (Granger, 1974). Real estate models often have been based on a long-run relationship existing between prices and income. One might expect that the two variables could diverge over a business cycle but eventually reestablish an equilibrium in the long run.

CPI Modeling Approach

Estimating and forecasting with VAR/VECM model follows a routinized approach similar to that of estimating an ARIMA model:

1. Model specification and variable selection/transformation.

2. VAR estimation and lag-length selection.
3. Cointegration test.
4. VECM estimation and results.
5. In-sample forecast and evaluation/model revision.
6. Future out-of-sample forecasting.
7. Model revision based on incoming data and expert opinion.

Specifying VAR models relies on underlying theoretical and applied knowledge of what variables to include. Choosing variables for a VAR model cannot be performed in an automated fashion, such as a stepwise regression in an ordinary least squares (OLS) single equation approach. Such approaches should be used with caution, as they can result in specifications with little to no economic theory. Additional factors must be considered when specifying augmented vector autoregression to include error-correction terms. The econometrician first must identify a set of two or more variables that he or she believes should have a long-run statistical relationship, which can be done using commonly used cointegration tests. A prerequisite is that all variables considered for a VECM model be unit root processes, which is tested using the augmented Dickey-Fuller unit root test (Dickey and Fuller, 1979).

Once a set of two or more variables is selected for estimation, lag selection is performed on the VAR model. Commonly employed information criteria are used to evaluate multiple lag specifications. The two most common measures are the Akaike information criterion (AIC) and the Schwarz information criteria (SIC). The two measures present theoretical tradeoffs between them that result in both choosing robust lag lengths, just under different assumptions. Both measures are approximately correct according to a different goal and a different set of asymptotic assumptions. The AIC criteria were used throughout the modeling process.

After lag selection was performed and a VAR was estimated, cointegration tests were performed to detect the presence of statistical long-run relationships between variables in the set. The Johansen procedure was used throughout the modeling process (Johansen, 1991). It is the most widely used and one of the most accepted multivariate cointegration tests. The test will detect *n*-1 possible cointegrating relationships in a group of *n* variables. If more than one long-run relationship is found, the modeler determines, through theory and expertise, what each cointegrating relationship represents.

The estimated VAR model is augmented with the cointegrating equations and reestimated as a VECM model. Both long-run cointegrating equations in levels are estimated alongside short-run equations in first differences that act to pick deviations from the theoretical long-run relationship. Coefficients are evaluated for both sign and statistical significance.

Forecasting the performance of each VECM was tested by benchmarking the VECM models against ARIMA models estimated by UrbanSim using auto-selection procedures. The auto-selection procedure followed a set of steps that included (1) transforming the variable into logs if needed, (2) differencing up to two times depending on the results of an ADF unit root test, (3) estimating up to an AR(4) MA(4) model by iterating over every combination and returning the model with the lowest AIC measure, and (4) forecasting seven quarters in-sample to provide a comparison to the VECM in-sample forecast. Forecast evaluation was performed by comparing the VECM model to both the ARIMA model and a simple weighted combination of the two. Precedent in the literature suggests that an ensemble approach to forecasting can reduce overall forecasting errors. The root mean squared error (RMSE) was used as the primary measure. The advantages of RMSE include (1) the errors are squared, penalizing outliers; and (2) the error is reported in native units of the dependent variable.

Rent of Primary Residence Model

The Rent CPI modeling process followed the steps laid out in the previous section. The first step was variable selection and model specification. As stated earlier, no agreed-upon way exists to choose a set of variables for a VAR model; the modeler must rely on a combination of economic theory and applied expertise. In addition, the desire to estimate a VECM model requires the modeler to develop and test a hypothesis of possible statistical relationships that should hold in the long run, according to theory.

An attempt was made at the outset of the Rent CPI modeling process to find a parsimonious set of variables that have strong economic linkages to the Rent CPI and could be used into the future if HUD chooses to operationalize multivariate models in the FMR process. After analyzing statistical correlations to avoid severe multicollinearity among choice variables and unit root tests to ensure that all included variables are nonstationary and, therefore, able to be modeled as a cointegrating vector, the FHFA all-transaction home price index and per capita disposable personal income were chosen to be included in the VECM models; appendix D summarizes the stationarity tests. In addition, the metro-level consumer price index for all items was used to generate both real home price and real income variables for use in the VECM models. The home price index was included as a supply-side proxy for the housing market, and the per capita disposable personal income variable is a demand-side proxy for households. Exhibit 3 displays the variables, sources, and frequencies.

Exhibit 3. Rent CPI Model Variables

Variable	Source	Frequency
Rent of Primary Residence CPI	BLS	Monthly, Bimonthly
All-Transactions House Price Index	FHFA	Quarterly
State Per Capita Disposable Personal Income	BEA	Quarterly, Annual
Consumer Price Index—MSA	BLS	Biannual, Annual

BEA = Bureau of Economic Analysis. BLS = Bureau of Labor Statistics. CPI = Consumer Price Index. FHFA = Federal Housing Finance Agency. Following the choice of variables to include in the VECM models, estimation and lag-length selection were performed. The Akaike information criteria were used for lag selection for all Rent CPI models. Lag selection results are shown in exhibit 4. As a comparison, the Schwarz information criteria would have selected almost all models with only one lag, which was thought to be overly restrictive in the modeling process.

Exhibit 4. Lag-Length Selection for Rent CPI Models

Area	Lag-Length—AIC Measure
Alaska	5

Atlanta	5
Baltimore	4
Boston	5
Chicago	5
Dallas	5
Denver	5
Detroit	4
Honolulu	5
Houston	5
Los Angeles	6
Miami	4
Minneapolis	5
New York/New Jersey	5
Philadelphia	5
Phoenix	5
San Diego	5
San Francisco	5
Seattle	5
St. Louis	7
Tampa	4
Washington, DC	4

AIC = Akaike information criterion. CPI = Consumer Price Index.

Source: Author’s calculations

The definition of *cointegration* states that two or more nonstationary variables may be combined in a linear combination that results in a stationary process. Variables considered for the Rent CPI VECM model must be nonstationary or a unit-root process so that they can be combined in a cointegrating model. Augmented Dickey-Fuller (ADF) unit root tests were performed on all variables included in the VECM models. The null hypothesis of the ADF is that the variable has a unit root. All variables failed to reject the null hypothesis with very small (in absolute values) ADF tau statistics. This result is to be expected, as all variables considered have a pronounced trend in the time series.

Johansen cointegration tests were run on each VECM model to confirm the presence of cointegration between the variables; the results appear in exhibit 5. With three variables included in each VAR model, at most, two long-term equilibrium relationships can exist.

Exhibit 5. Rent CPI VECM Model Cointegration Test

Area	# of Cointegrating Relationships	Probability Value Null Hypothesis: No Cointegration
Alaska	1	0.02
Atlanta	1	0.00
Baltimore	1	0.06
Boston	1	0.00
Chicago	1	0.03
Dallas	1	0.11
Denver	1	0.00
Detroit	1	0.01
Honolulu	1	0.10
Houston	1	0.03
Los Angeles	1	0.08
Miami	1	0.04

Minneapolis	1	0.00
New York	1	0.01
Philadelphia	1	0.00
Phoenix	2	0.00, 0.00
San Diego	1	0.06
San Francisco	1	0.01
Seattle	0	0.29
St. Louis	1	0.11
Tampa	1	0.03
Washington, DC	1	0.02

CPI = Consumer Price Index. VECM = vector error correction model.

After performing unit root tests on all included variables, performing lag selection using the AIC measure, and testing for the presence of cointegration using the Johansen procedure, the VECM models were estimated for each metro area. A training set was estimated from the earliest available data point, which varied from 1985 to 1990 depending on the region, through 2019Q1. The period of 2019Q2 through 2020Q4 was used as a test set for in-sample forecasting and evaluation. The auto-specification procedure for benchmark ARIMA models was also completed at this step. Complete estimation results for both ARIMA and VECM models can be found in appendix A.

The forecast evaluation relied on the mean absolute percentage error because it allows for easy comparison across regions. The VECM model was compared with the auto-selected ARIMA specification and an equally weighted forecast combination. Building ensembles of different forecast methodologies can result in an overall smaller mean absolute percentage error (MAPE) and take advantage of multiple modeling methodologies. Appendix A shows the full forecast evaluation results, and exhibit 6 displays a summary of each regional forecasting model.

Exhibit 6. Rent CPI Forecast Evaluation Approach—VECM and ARIMA (2019Q2–2020Q4)

Area	MAPE VECM	MAPE ARIMA	MAPE Combination
Alaska	**1.21**	1.29	1.28
Atlanta	0.63	1.07	**0.42**
Baltimore	**2.41**	5.73	3.21
Boston	**1.24**	3.48	2.36
Chicago	**0.97**	1.82	1.57
Dallas	**1.28**	2.61	1.91
Denver	**0.37**	0.80	0.58
Detroit	0.75	**0.45**	0.52
Honolulu	1.83	**1.20**	1.51
Houston	**0.55**	1.09	0.68
Los Angeles	1.02	**0.53**	0.69
Miami	**1.07**	1.20	1.14
Minneapolis	1.20	**0.43**	0.81
New York/New Jersey	**0.57**	0.87	0.58
Philadelphia	0.64	0.37	**0.34**
Phoenix	2.63	**2.16**	2.40
San Diego	**0.73**	0.73	0.73
San Francisco	**2.49**	2.63	2.56
Seattle	1.02	1.62	**0.89**
St. Louis	**0.90**	1.11	1.04

Tampa	1.04	**0.64**	0.84
Washington, DC	**0.97**	2.21	1.56

ARIMA = autoregressive integrated moving average. CPI = Consumer Price Index. MAPE = mean absolute percentage error. Q = quarter. VECM = vector error correction model.

Note: The lowest mean absolute percentage error is shown in bold, indicating the highest accuracy model for each area.

The forecast evaluation resulted in 13 of 22 metro-area VECM models outperforming the ARIMA models in an eight-quarter in-sample forecast on an absolute basis. Six of the ARIMA models outperform the VECM models, and three of the simple mean combination models outperform both the VECM and ARIMA models.

A second forecasting exercise was completed to evaluate the VECM approach against autoregressive distributed lag models (ARDLs) that followed a similar specification as the local versions of existing HUD models. As discussed in a 2019 2M research report, the HUD local ARDL models were estimated with local exogenous factors that included Census Bureau local permit data and BLS local employment data. All 22 regions were specified in first differences and included a first-order moving average (MA[1]) term to help capture the time series dynamics of the rent series and two lags of both permit and employment data to capture local economic dynamics. All models were estimated from the beginning of the sample, which varied by region through 2018Q1. The in-sample forecast evaluation was performed over the sample of 2018Q2 through 2019Q4, excluding any effects from the COVID-19 pandemic. In addition, without having the exogenous forecasts for permits and employment that HUD would have included over the time horizon, the estimated ARDL models rely on the actual, observed data for all exogenous variables. Forecast evaluation results are shown in exhibit 7.

Exhibit 7. Rent CPI Forecast Evaluation Approach—VECM and HUD ARDL (2018Q2–2019Q4)

Area	MAPE VECM	MAPE HUD
Alaska	**0.69**	1.99

Atlanta	**1.93**	2.21
Baltimore	1.28	**1.14**
Boston	**0.60**	0.94
Chicago	0.52	**0.22**
Dallas	1.66	**0.92**
Denver	**0.22**	0.81
Detroit	**0.46**	1.05
Honolulu	**0.49**	0.63
Houston	**0.82**	1.29
Los Angeles	**0.74**	1.34
Miami	0.70	**0.56**
Minneapolis	**1.01**	1.49
New York/New Jersey	1.15	**0.86**
Philadelphia	0.55	**0.32**
Phoenix	2.27	**2.12**
San Diego	2.59	**0.11**
San Francisco	1.57	**1.49**
Seattle	**0.63**	0.96
St. Louis	**0.41**	0.59
Tampa	1.48	**1.30**
Washington, DC	**1.16**	1.78

ARDL = autoregressive distributed lag models. CPI = Consumer Price Index. MAPE = mean absolute percentage error. Q = quarter. VECM = vector error correction model.

Note: The lowest mean absolute percentage error is shown in bold, indicating the highest accuracy model for each area.

The VECM model outperformed the HUD ARDL model in 12 of 22 regions based on root mean squared error over the 2018-through-2019 period.

A second forecast evaluation was performed with the VECM and HUD ARDL models over the in-sample period of 2019Q2 through 2020Q4. This in-sample evaluation includes the onset of the COVID-19 pandemic. The HUD ARDL models are specified with the same exogenous variables, and actual observed data are used to drive the forecast over the horizon. This method contrasts with what exogenous forecasts HUD would have used in 2019 before knowing of the oncoming pandemic. Exhibit 8 shows the forecast results.

Exhibit 8. Rent CPI Forecast Evaluation Approach—VECM and HUD ARDL (2019Q2–2020Q4)

Area	MAPE VECM	MAPE HUD
Alaska	**1.59**	2.33
Atlanta	**1.17**	2.43
Baltimore	**3.31**	3.79
Boston	**0.35**	0.97
Chicago	0.33	**0.16**
Dallas	2.61	**1.36**
Denver	1.15	**0.61**
Detroit	**1.01**	1.58
Honolulu	**2.57**	2.65
Houston	**1.68**	1.63
Los Angeles	**0.85**	1.52
Miami	1.92	**1.80**
Minneapolis	**1.37**	1.56

New York/New Jersey	**0.53**	0.74
Philadelphia	**0.33**	1.21
Phoenix	**2.07**	2.46
San Diego	**0.23**	1.19
San Francisco	**1.91**	2.14
Seattle	**1.04**	1.45
St. Louis	**0.78**	1.01
Tampa	**0.36**	1.34
Washington, DC	**0.37**	0.55

ARDL = autoregressive distributed lag models. CPI = Consumer Price Index. MAPE = mean absolute percentage error. Q = quarter. VECM = vector error correction model.

Note: The lowest mean absolute percentage error is shown in bold, indicating the highest accuracy model for each area.

The VECM model outperformed the HUD ARDL model in 18 of 22 regions based on root mean squared error over the 2019-through-2020, period which included the onset of the COVID-19 pandemic.

Utilities and Fuels CPI Component Model

The Fuel CPI modeling process followed a similar process as the Rent CPI modeling exercise. The first step was variable selection and model specification. As stated earlier, no agreed-upon way exists to choose a set of variables for a VAR model. The modeler must rely on a combination of economic theory and applied expertise. In addition, the desire to estimate a VECM model requires the modeler to develop and test a hypothesis of possible statistical relationships that should hold in the long run according to theory. That process was performed using the Johansen cointegration test, with results reported in Exhibit 11.

The Fuels and Utilities CPI component has underlying subcomponents that represent household energy prices for electricity and fuels. Precedent exists for modeling crude oil prices in a VAR representation, with products derived from crude, such as gasoline, kerosene, and jet fuel (Baumeister, Kilian, and Zhou, 2017). Working from that approach, it was thought that modeling the Fuel CPI component with individual energy prices such as natural gas, electricity, and crude oil could provide increased information to the models. The Producer Price Index is also included to transform nominal prices into real prices for the model process.

Exhibit 9. Fuel and Utilities CPI Model Variables

Variable	Source	Frequency
Fuel and Utilities CPI	BLS	Monthly, Bimonthly
Henry Hub Natural Gas Price	EIA	Monthly
Electricity per kWh, U.S. City Average	EIA	Monthly
WTI Crude Oil Price	EIA	Monthly
Producer Price Index: All Commodities	BLS	Monthly

BLS = Bureau of Labor Statistics. CPI = Consumer Price Index. EIA = U.S. Energy Information Administration. kWh = kilowatt-hour. WTI = West Texas Intermediate.

Following the choice of variables to include in the VECM models, estimation and lag-length selection were performed. The Akaike information criteria were used for lag selection for all Fuel and Utilities CPI models. Lag-length selection results are shown in exhibit 10.

Exhibit 10. Lag-Length Selection for Fuel and Utilities CPI Models

Area	Lag-Length—AIC Measure
Alaska	4
Atlanta	3
Baltimore	6
Boston	4
Chicago	5
Dallas	4

Denver	4
Detroit	2
Honolulu	2
Houston	3
Los Angeles	3
Miami	2
Minneapolis	4
New York/New Jersey	4
Philadelphia	4
Phoenix	4
San Diego	4
San Francisco	2
Seattle	2
St. Louis	6
Tampa	4
Washington, DC	5

AIC = Akaike information criterion. CPI = Consumer Price Index.

The definition of cointegration states that two or more nonstationary variables may be combined in a linear combination that results in a stationary process. Variables considered for the Fuel and Utilities CPI VECM model must be nonstationary or a unit root process so that they can be combined in a cointegrating model. Augmented Dickey-Fuller (ADF) unit root tests were performed on all variables included in the VECM models. The null hypothesis of the ADF is that the variable has a unit root. All variables failed to reject the null hypothesis with very small (in absolute values) ADF tau statistics—a result that was expected because all variables considered have a pronounced trend in the time series.

Johansen cointegration tests were run on each VECM model to confirm the presence of cointegration between the variables (exhibit 11). With three variables included in each VAR model, two long-term equilibrium relationships can exist at most.

Exhibit 11. Fuel and Utilities CPI VECM Model Cointegration Test

Area	# of Cointegrating Relationships	Probability Value Null Hypothesis: No Cointegration
Alaska	0	0.54
Atlanta	1	0.09
Baltimore	~1	0.11
Boston	~1	0.13
Chicago	~1	0.12
Dallas	~1	0.11
Denver	1	0.06
Detroit	1	0.01
Honolulu	~1	0.14
Houston	1	0.08
Los Angeles	0	0.49
Miami	1	0.04
Minneapolis	0	0.42
New York/New Jersey	1	0.01
Philadelphia	1	0.05
Phoenix	0	0.17
San Diego	1	0.06
San Francisco	~1	0.11
St. Louis	~1	0.14

Seattle	0	0.14
Tampa	1	0.08
Washington, DC	1	0.01

* Because the ADF test results were inconclusive, a 10-percent p-value was used as a threshold for cointegration. ~ = approximately.

CPI = Consumer Price Index. MAPE = mean absolute percentage error. Q = quarter. VECM = vector error correction model.

After performing unit root tests on all included variables, performing lag selection using the AIC measure, and testing for the presence of cointegration using the Johansen procedure, we estimated the VECM models for each region. A training set was estimated from the earliest available data point, which varied from 1985 through 1990 depending on the region, through 2018Q4; 2019Q1 through 2020Q4 was used as a test set for in-sample forecasting and evaluation. The auto-specification procedure for benchmark ARIMA models was also completed at this step. Appendix A presents complete estimation results for both ARIMA and VECM models.

The forecast evaluation relied on the root mean squared error. The VECM model was compared with the auto-selected ARIMA specification and an equally weighted forecast combination. Many ways can be used to develop combination forecasts, but equally weighting the two has been shown to be as effective in lowering the MAPE as any other statistical approach. Appendix A presents the full forecast evaluation results. Exhibit 12 shows a summary of each regional forecasting model.

Exhibit 12. Fuel and Utilities CPI Forecast Evaluation Approach—RMSE Fuel and Utilities CPI

Area	MAPE VECM	MAPE ARIMA	Combination
Alaska	2.75	**2.23**	2.44
Atlanta	3.45	**1.89**	2.27
Baltimore	0.87	0.96	**0.90**
Boston	7.42	**3.60**	5.51

Chicago	**0.87**	7.72	4.03
Dallas	3.27	**2.61**	2.76
Denver	5.68	**2.66**	3.95
Detroit	3.65	**2.53**	3.01
Honolulu	**2.43**	9.36	5.55
Houston	4.52	**4.02**	4.27
Los Angeles	**0.73**	0.96	0.81
Miami	**0.74**	1.46	1.03
Minneapolis	0.99	**0.54**	0.77
New York/New Jersey	**4.36**	4.76	4.40
Philadelphia	1.22	**1.07**	1.14
Phoenix	**6.95**	8.01	7.48
San Diego	**2.68**	5.65	4.01
San Francisco	1.14	**0.72**	0.77
Seattle	3.32	**2.84**	3.08
St. Louis	**8.92**	10.97	9.33
Tampa	2.46	**1.91**	2.19
Washington, DC	3.21	**2.98**	3.01

ARIMA = autoregressive integrated moving average. CPI = Consumer Price Index. MAPE = mean absolute percentage error. Q = quarter. RMSE = root mean squared error. VECM = vector error correction model.

Note: The lowest mean absolute percentage error is shown in bold, indicating the highest accuracy model for each area.

The forecast evaluation resulted in 8 of 22 metro-area VECM models outperforming the ARIMA models in an eight-quarter in-sample forecast on an absolute basis. Thirteen of the ARIMA models outperformed the VECM models, and one of the combination models outperformed both the VECM and ARIMA models.

Rapidly Rising Rent Analysis

Statistical Approach

The pace of rental price appreciation in many metro and sub-metro areas has become an issue of concern for low-income families and policymakers. As with any issue, being able to accurately define the problem is a crucial first step in implementing an effective response. Identifying metro areas with above-trend rent growth is a difficult problem to solve. We implemented a statistical approach, letting the data inform the problem rather than making assumptions that could be clouded with bias or judgment. Three approaches were tested: a cointegration model to try to identify periods of disequilibrium in rental market fundamentals, rent-to-income ratios, and decomposing rent series into cyclical and trend components using band-pass filters. All three methods are described below. Ultimately, the band-pass filter approach was chosen as the most robust and was implemented on an alternative rent data set originating from Apartment List. This dataset is released monthly and, after investigation, is believed it to be more representative of real-time market conditions.

The first approach used was to identify disequilibrium in FMR metro markets by relying on the theory of cointegration and estimate statistical, long-run regression models. The model took the form of an ordinary least squares (OLS) regression and followed the well-known Engel-Granger (1987) two-step procedure. The dependent variable was a measure of rental prices proxied by metro-level personal shelter consumer prices indices. The independent variables included a combination of fundamental supply and demand factors for the rental real estate market, including, but not limited to, measures of income, housing activity, population and household totals, and other long-term measures of real estate markets. When variables are expressed in level form, the equation represents the long-run equilibrium relationship between the prices and the included set of independent variables. The residual from the resulting regression represents the amount of variation in the dependent variable not explained by the specification. In that case, the residual represents deviations from long-run equilibrium in prices. The residual can be standardized and compared across metro regions to identify markets that display prices above or below equilibrium. Advantages to this approach include relying on well-known statistical methods that are transparent and reproducible with publicly available data; representing the market as a combination of long-run supply and demand drivers rooted in underlying real estate economic theory; using long-standing, proven econometric methodologies, such as cointegration and error correction; and the ability to compare across multiple MSA markets with similar data driving each estimation.

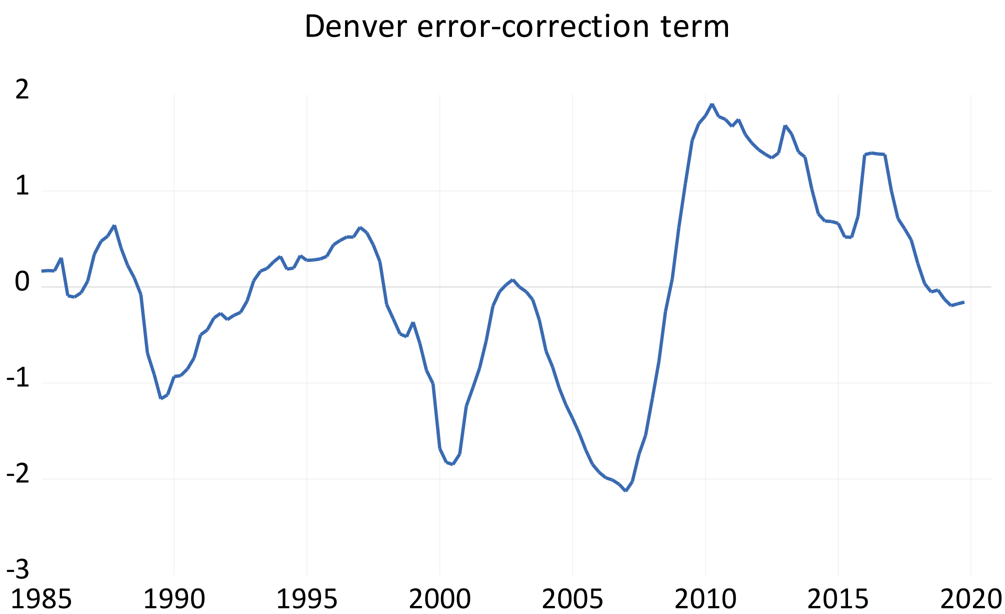
The second approach was deriving rent-to-income ratios using the CPI primary rent and real personal disposable income series. Although this approach is not as econometrically involved as the Engel-Granger approach, it can be used to help identify current states of rental markets with respect to economic fundamentals. This approach can also be used to help verify the results from other approaches.

The third approach was to use band-pass (BP) filters to statistically decompose rent series into a long-run structural trend and a number of underlying cyclical series (Baxter and King, 1995). For example, a common approach is to use BP filters to decompose real gross domestic product (GDP) into a trend component that is thought to represent potential GDP and a business-cycle component with a periodicity of 2 to 8 years, which represents deviations from the long run. This approach has advantages when dealing with trending time series, such as the Rent of Primary Residence CPI component. The Christiano-Fitzgerald Asymmetric filter was used to decompose quarterly Rent CPI series into trend and business-cycle components (Christiano and Fitzgerald, 1999). Housing makes a significant contribution to overall U.S. economic growth, so looking at the business-cycle frequency is a starting point for this type of analysis.

Summary of Results

The first approach used was the Engel-Granger cointegration approach. Ordinary least squares regressions were run on the log of all Rent CPI series. Independent variables included the log of real per capita disposable income and the log of real home prices. Dickey-Fuller unit root tests were performed on the residuals to check for stationarity. If stationarity was found, the residuals could be interpreted as the long-run error-correction mechanism with respect to the underlying linear estimation. All residual graphs are shown in appendix B. The scaling was normalized so that interpretation would be units of standard deviation. Using this framework, one could look at periods when the relationship increased 2 or more standard deviations, toward a value of positive 1 or 2, at which the relationship historically would begin to mean revert. Exhibit 13 illustrates the error-correction term for Denver as an example.

Exhibit 1. Denver Error-Correction Term

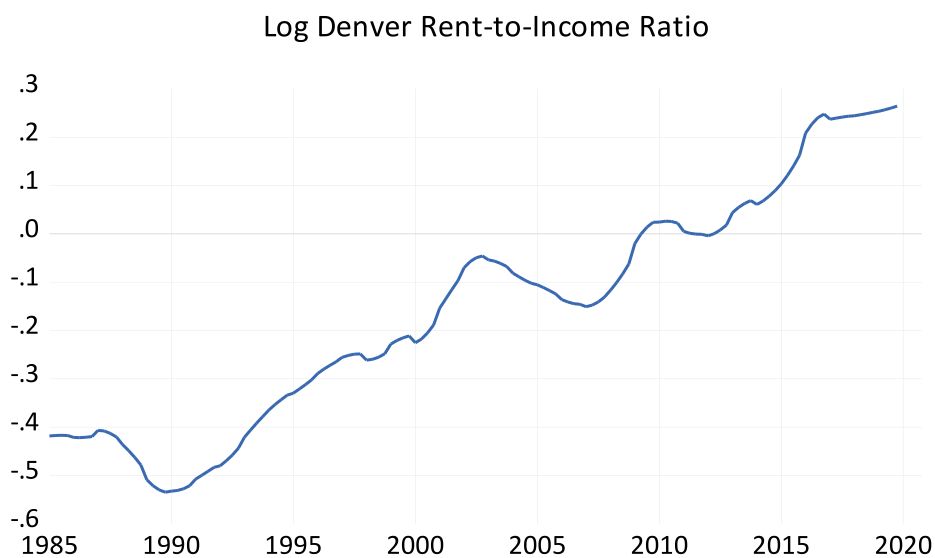


Source: Author's calculations

The residual was assumed to be stationary based on the unit root tests. The residual or error-correction term hit the lowest point at roughly 2 standard deviations below the mean and then had a 4-standard-deviation move, from -2 toward +2, over the period of 2007Q2 through 2010Q2. This relationship must be interpreted as the equilibrium relationship between rent, income, and home prices. The specification could be changed to include other fundamental long-run drivers, but the requirement of the error-term being stationary is necessary for interpretation as a mean-reverting term. To identify periods of rising rents, the error-correction term could transform into first differences to determine if it is increasing or decreasing and then transformed into second differences to determine if it is increasing or decreasing at an increasing or decreasing rate. Doing so can capture the idea of acceleration in prices and determine whether rents are in a state of "rapid increase."

Rent-to-income ratios were calculated for metro regions as additional way to look at relative changes and help understand periods, for example, when rents increased much faster than income. Rent-to-income ratios for all 22 regions demonstrated an outpacing of rental price appreciation relative to real incomes, which should not be surprising given the stagnation in real wages and incomes over the past two decades. Exhibit 14 shows the log of rent-to-income ratio for Denver.

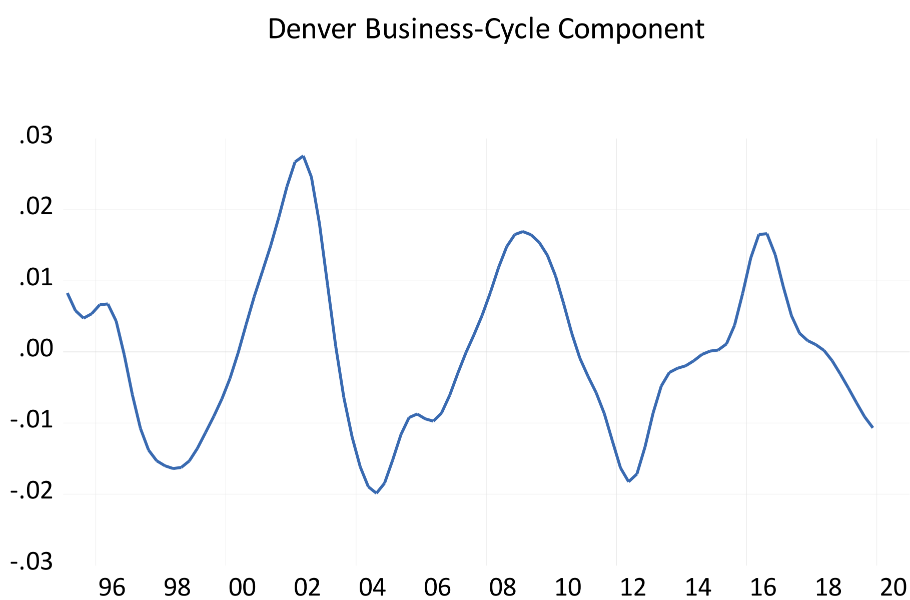
Exhibit 2. Log of Denver Rent-to-Income Ratio



Source: Author's calculations

The third approach discussed was using band-pass filters to isolate the underlying long-run trend from higher frequency cyclical movements in rental prices. Those techniques have been widely used in applied macroeconomics and finance to analyze the business cycle (BC) of an underlying economy. The advantage of using band-pass filters is the ability to separate a trending variable from its underlying cyclical movements. Many macroeconomic variables including the CPI and its components almost appear to monotonically increase, making any determination of whether prices are rising or rapidly rising difficult to determine. The Christiano-Fitzgerald asymmetric filter was applied to the log of the Rent CPI series to specifically isolate a cycle of 2 to 8 years in length. The 2- to 8-year frequency is commonly used for business-cycle analysis and has been used to look at housing and its relationship to the broader macroeconomy. The chart for all business-cycle rent components is shown in appendix B. Continuing with Denver as an example, exhibit 3.3 shows the business-cycle component.

Exhibit 3. Denver Business-Cycle Component



Source: Author's calculations

The graph represents deviations from the filtered long-run trend in the underlying data. When the component is above the zero axis, the Denver rent CPI can be said to be increasing in an above-trend way. Determining if the business-cycle component is increasing or decreasing at an increasing or decreasing rate can help determine if prices are in a state of rapidly rising rents.

The first and second differences were taken to understand when each of the three residual series is increasing or decreasing at an increasing or decreasing rate. All three methods can be compared to see where they align. Exhibit 16 displays a snapshot of the Denver region. The first column is the error-correction term, followed by the band-pass filter cycle, and finally the rent-to-income ratio. At the peak of the housing boom in the mid-2000s, all three methods were signaling that rents were increasing at an increasing rate. The middle column shows that after the onset of the Great Recession, the cyclical component turned sharply to a state of decreasing at an increasing rate, picking up the relation to the overall business cycle. Dashboards for all 22 metro areas are shown in appendix C.

Exhibit 16. Denver Model Comparison: Error-Correction, Band-Pass, and Rent-to-Income Ratio

Period	Error-Correction	Band-Pass	Rent-to-Income Ratio
2007Q1	RD	RR	RD
2007Q2	RR	R	RR
2007Q3	RR	R	RR
2007Q4	R	RR	RR
2008Q1	RR	RR	RR
2008Q2	R	RR	RR
2008Q3	RR	R	RR
2008Q4	R	R	RR
2009Q1	RR	R	RR
2009Q2	R	RD	R
2009Q3	R	RD	R
2009Q4	R	RD	R
2010Q1	R	RD	R
2010Q2	RR	RD	RR
2010Q3	RD	RD	RD
2010Q4	D	D	RD

D = Decreasing at a decreasing rate. R = Increasing at a decreasing rate. RD = Decreasing at an increasing rate. RR = Increasing at an increasing rate.

Source: Author's calculations

As an alternative case, all metro areas picked up the downturn in the economy and rental market because of the coronavirus pandemic. In almost all cases, all three signals turned negative and many to rapidly decreasing rental prices throughout all of 2020.

All three approaches to statistically identifying periods of rapidly rising rents are data-driven in their approach and provide insights into how various fundamentals drive rental markets. After analyzing how each method compared across metropolitan areas, the band-pass filtering approach was selected as the most robust and consistent for identifying when markets are experiencing extreme movements in price.

BP filters do not rely on estimating any structural equations and focus on only how cyclical components of trending series move. One advantage of this approach is that it can be updated frequently without needing other exogenous variables for analysis. Band-pass filtering also showed a more consistent result across periods when compared with the cointegration and rent-to-income ratio approaches. The BP approach can identify periods of rapidly rising and falling rents without the frequent reversals seen in both of the other approaches.

Alternative Data Sets and Case Study

Additional datasets were analyzed to look for differences in how rent prices evolve over time. We compared REIS, Craigslist, Apartment List, and Zillow rent data with the Rent CPI series for a set of metro areas. One noticeable difference was that the alternative data seemed to react in a much more pronounced way than the Rent CPI data to the COVID-19 pandemic. The difference, of course, could be explained in the way the data are calculated, but it does give a very different picture of how rents have evolved since the pandemic began. A notable point is that most of these alternative datasets are derived from real-time market conditions for rental contracts or listings rather than a survey-based method.

Apartment List data are available monthly starting in 2017 and include all 22 metro regions covered in this study. The entire Apartment List database covers state, region, metro, and city-level geographies.[1] The band-pass filter approach to identifying areas with rapidly rising rents could be implemented below FMR-designated geographies. Those data were used for an additional case study within the BP filter framework and analyzing how the most current Apartment List data compares with the recently released FY22 FMR calculations.

The Christiano-Fitzgerald band-pass filter was applied to the log of all 22 Apartment List rent series. The same underlying assumptions of nonstationarity were used in the calculation. The decomposition included

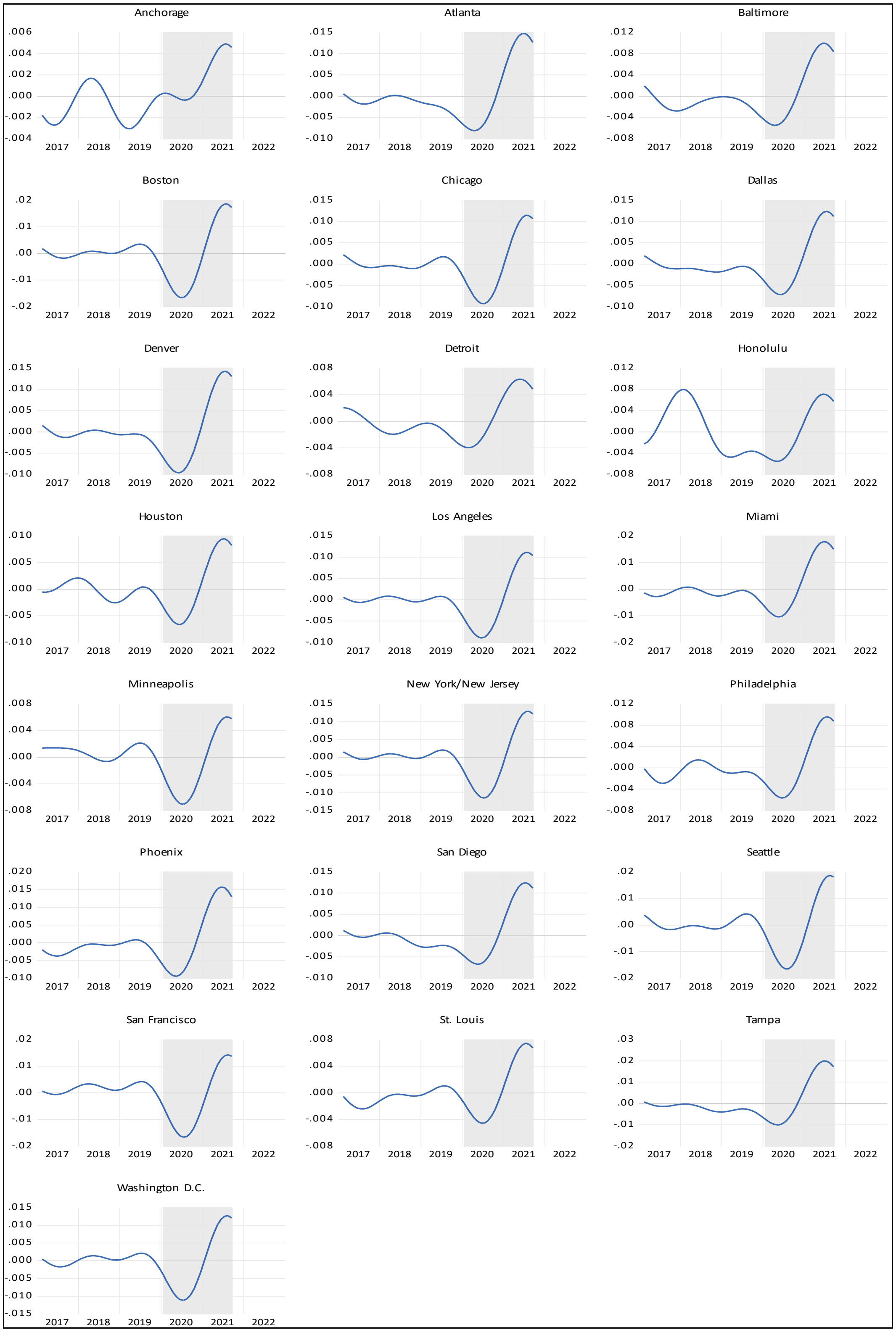
[1] For a more detailed description of the Apartment List data, see https://www.apartmentlist.com/research/rent-estimate-methodology.

the entire monthly sample from January 2017 through September 2021. Exhibit 17 illustrates the business-cycle component for each metro area, and exhibit 18 shows the rate of change of the business-cycle component. All graphs are shaded to highlight when the pandemic began.

Exhibit 17. Deviations from Rent Trend by Metro Area

Source: Author’s calculations

Exhibit 18. Rate of Change of Deviations from Rent Trend



Source: Author's calculations

The first graph containing the business-cycle component for each of the 22 metros highlights the cyclical nature of rents as the pandemic began in 2020. The deviations from trend ranged from -2 to -12 percent in some areas. What is consistent is the cyclical downturn in all 22 areas and the subsequent acceleration in the business-cycle components beginning in early 2021. Most of the 22 areas had moved back into above-trend growth (where the cyclical component moved above the zero line) by the third quarter of 2021.

The second graph contains the rate of change (first difference) of the business-cycle components, which is equivalent to measuring the acceleration of the cyclical components and is used to identify areas with rapidly rising rents. If a metro area's cyclical component is increasing at an increasing rate, rents are assumed to be rapidly rising. The second graph highlights that most of the 22 areas were experiencing acceleration in the business-cycle component throughout the first half of 2022.

Combining the band-pass filtering methodology with a monthly, market-derived dataset such as Apartment List could help identify periods of rapidly rising rents that could inform and update FMRs that are in place until the next forecast cycle is completed. An additional advantage to the Apartment List data is that they cover state, regional, metro, and city-level geographies for more than 500 rental markets, which would give HUD the ability to identify smaller areas experiencing rising rents with real-time data. That component highlights the flexibility of using the band-pass approach, which requires only a single time series of rents for any area under analysis.

The Apartment List data are current through September 2021. The September two-bedroom rent can be compared with the HUD FY22 50-percent FMRs as currently calculated to determine any significant differences. Exhibit 19 contains the HUD two-bedroom FY22 FMR, Apartment List September 2021 two-bedroom rent, and the percentage difference.

Exhibit 19. Comparison of HUD 50th Percentile Rents and Apartment List Rents

Metro Area	HUD FY22 50th Percentile Rent 2-Bed ($)	Apartment List Sept. 2021 Rent 2-Bed ($)	Percentage Difference (%)
Anchorage	1,335	1,503	-12.58
Atlanta	1,397	1,548	-10.10
Baltimore	1,518	1,680	-10.67
Boston	2,583	2,004	22.41
Chicago	1,456	1,373	5.70
Dallas	1,477	1,429	3.24
Denver	1,800	1,746	3.00
Detroit	1,162	1,148	1.20
Los Angeles	2,255	2,088	7.41
Miami	1,814	1,895	-4.44
Minneapolis	1,432	1,312	8.37
New York/New Jersey	2,505	1,873	25.22
Philadelphia	1,399	1,413	-1.00
Phoenix	1,417	1,687	-19.05
San Diego	2,433	2,298	5.55
Seattle	2,185	1,904	12.86
St. Louis	1,015	1,112	-9.55
Tampa	1,452	1,697	-16.87
Washington, DC	1,927	1,891	1.86

FMR = Fair Market Rent. FY = fiscal year.

Source: HUD, Apartment List

Eight of 19 Apartment List metro rents were greater than the HUD FY22 calculated FMRs as of September 2021. The percentage difference for the eight metro areas ranged from 1 to 19 percent above HUD FMR values. Considering that those differences were calculated in September 2021, the acceleration in rents according to the Apartment List data could increase, albeit at a slower rate, but continue to create an even larger gap between HUD FMRs and market list rents. That discrepancy in market rents between datasets presents an opportunity to align—in real time—HUD FMRs and current pricing. A mechanism could be developed wherein the Apartment List monthly data are continuously updated and analyzed using the band-pass filter technique. If the acceleration in rents (the rate of change in the business-cycle component) is found to be increasing for some given number of months—say, 4 to 7 months—then an adjustment can be made to FMRs to align the static FMRs more closely with current market conditions. That effort could potentially prevent housing authorities from being required to undertake costly surveys to submit a request for an increase in local FMRs. In addition, that approach might be timelier to the needs of households looking for affordable housing. A fully outlined example is shown below.

Hypothetical Rent Adjustment Process:

1. Obtain updated monthly Apartment List rental data for current month.
2. Transform the monthly time series into the natural log.
3. Implement the Christiano-Fitzgerald Asymmetric BP filter with business-cycle frequency.
4. Take the first difference of the business-cycle component.
5. Compare with last month(s) to verify whether prices continue to accelerate.
6. If persistent acceleration triggers a threshold of 4 months or more, adjust FMRs upward.

Conclusions

Making material improvements to two separate components of the HUD FMR trend market could have great importance for the way housing program voucher assignment and, ultimately, access to affordable housing are determined. In addition, developing statistical methodology to help identify markets that might be experiencing rapidly rising rents complements the trend factor modeling for the FMR update. The approach undertaken here was to test the efficacy and accuracy of multivariate time series approaches to modeling the Rent of Primary Residence CPI component and the Fuels and Utilities CPI component. The working hypothesis was that adding in additional economic drivers to model each component could produce more accurate forecasts and include economic theory in the modeling approach.

The econometric methodology used for this study included modeling the two CPI components in a vector autoregression/vector error correction framework. Those models treat all variables as endogenous and focus more on the underlying statistical properties and interaction of the data rather than trying to model the components as single equations with exogenous supply-and-demand relationships being estimated. In addition to using a VAR approach, another statistical approach was tested and implemented where appropriate. The theory of cointegration allows two or more stochastic time series to be modeled together, resulting in a long-run equilibrium relationship that results in variables not being able to diverge in the long run.

The Rent of Primary Residence CPI component was modeled as a VECM for 22 metro areas across the United States. Variables included in the VECM models included the Rent CPI component, a measure of real home prices, and a measure of real disposable personal income per capita. Long-run cointegrating relationships were found in all but one metro area and implemented in the model. Training and test sets were identified, and a seven-quarter in-sample forecast was used to evaluate the accuracy of the VECM model, benchmarked against both pure time series ARIMA models and autoregressive distributed lag models (ARDL), following HUD’s approach to including local exogenous factors. The multivariate

VECM model was evaluated against both an ARIMA time series model and an ARDL HUD model over the in-sample forecast horizon of 2018 through 2019. That timeframe was chosen to test the models in a more “normal” economic environment as compared with the current pandemic-driven environment. The VECM model outperformed the ARIMA model in 14 of 22 metro areas and the HUD ARDL model in 12 of 22 areas. The VECM was also evaluated against the HUD ARDL model over the period of 2019 through 2020, which included the pandemic. The VECM model outperformed the HUD ARDL model in 18 of 22 metro areas.

The Fuel and Utilities CPI component has been modeled in the past as a pure time series model with little improvement offered from including an additional regressor to the ARIMA(X) models. We proposed the VAR/VECM approach for the Fuel CPI component. The hypothesis was that individual energy prices may have explanatory power in helping explain past and future Fuel and Utilities CPI movements. Variables under consideration included WTI crude, Henry Hub natural gas prices, and U.S. city average electricity prices. Ultimately, natural gas and electricity prices were used in the VECM models. The WTI price was entering early VAR specification, with little to no interaction with the other three variables. All variables under consideration were unit root processes and could be considered for cointegrating relationships with the VECM framework. Identifying strong statistical cointegrating relationships was much more difficult. Many of the regions’ cointegration tests were only significant at the 10-percent level or slightly higher. We decided that cointegrating relationships would still be imposed on those models that fell within that range. For any model that was outside the near-10-percent range, a VAR in first differences was estimated and used for the forecast evaluation. Eight of 22 VECM models outperformed the ARIMA models, which was not surprising due to the weaker statistical relationships that emerged in the VECM modeling process. The Fuel and Utilities CPI component has volatility that was difficult to characterize as purely seasonal; therefore, adjusting for seasonality did not improve the VECM model performance. The VECM model was not evaluated against any HUD-specific models for the fuel and utilities component because a similar ARIMA approach has been used by HUD.

Identifying markets with rapidly rising rents was an additional research question to be investigated. Not only is this issue important for how the HUD FMR program addresses people's needs, it also can help inform the approaches taken in setting the FMR through the trend factor modeling process. We investigated various statistical approaches to help better understand this question, including a fundamental approach using cointegration theory to model the equilibrium state of a rental market, calculating rent-to-income ratios, and using statistical decomposition techniques to isolate trend and cyclical components in trending rent series. Ultimately, the band-pass filtering approach was chosen as the most robust and offering the most flexibility for the research questions at hand.

Multiple alternative datasets were evaluated. Monthly market rent data from Apartment List were used in a case to study to implement the band-pass filtering approach to identifying markets with rapidly rising rents and using that information as an adjustment mechanism for published HUD FMRs. We outlined a workflow that included using the recuring monthly Apartment List data to determine if a market is "rapidly rising" and then adjusting HUD FMRs to close the gap. That new approach could complement the way housing authorities currently perform surveys and make requests for FMR increases when they identify markets that have experienced accelerating prices. In addition, the alternative dataset is available for 500 cities and all 50 states, allowing for the implementation of robust statistical tools at a small geographic level.

The work done in this modeling project offers new and possibly improved methods for updating the FMR trend factor components. More work could be done testing additional variables that could help improve the forecasting performance. In addition, smoothing techniques could be applied to the Fuel CPI component to model the underlying trend and improve the interaction with the energy prices used in this analysis. Identifying past periods of rapidly rising rents across metro regions is possible with a combination of statistical tools, implementing newer machine learning algorithms to large datasets of real-time data, which could help identify whether an area is currently in a period of rapidly rising rents. Further research could be directed at better understanding the differences between both publicly available and proprietary datasets on rent prices. This modeling effort has revealed significant differences in price movements depending on which source is being evaluated, which could provide additional improvement to the overall FMR modeling process, especially in smaller areas where government data are not available on a real- or near-time basis.

Final Considerations and Next Steps

2019 Senate Committee on Appropriations Report (S. Rept. 116-109)

"The Committee is concerned that where there is a significant fluctuation in local rental market conditions, HUD's published fair market rents **do not reflect the increased need in rental subsidy and the associated operating costs.** As a result, some PHAs are conducting independent market surveys to more accurately reflect local market conditions for HUD's review and consideration. However, some rental market surveys can be costly and an unviable option for PHAs that lack the expertise and capacity. This is particularly true for smaller PHAs in markets where the local fair market rents are outpacing HUD's annual determination of FMRs."

COVID-19 Impact

In the intervening time since the Senate's report, the issuance of the NOFA for this study (6/2/2020), and the selection of the research teams (11/30/2020), the COVID-19 pandemic has continued to have an impact on the economy, rental housing costs, utility costs, and inflation. The Census Bureau announced in November 2021 that as a result of the pandemic impacts on the American Community Survey (ACS), the 2020 ACS 1-year data do not meet its data quality standards (U.S. Census Bureau, 2022, n.d.). The pandemic may have similar impacts on 2021 ACS 1-year data and possibly into 2022 and beyond.

Inflation has also been increasing rapidly and, according to the January 2022 Department of Labor report increased in December 2021, at the fastest rate in 40 years. Increases in rental housing costs typically begin slowly and remain high once they rise. Even without the ACS 1-year data quality issue described above, the current Consumer Price Index (CPI) methodology used to calculate FY 2022 Fair Market Rents (FMRs), which includes Rent of Primary Residence, does not pick up those inflationary impacts in real time because it is only produced every 6 months. The ACS 1-year data used for the CPI calculations will continue to pose an issue at a minimum for FY 2023 and FY 2024 FMRs.

Alternative Methodologies

The opportunity and necessity to do something different on an ongoing rather than a temporary basis clearly exist. HUD has publicly stated as much, and with the December 9, 2021, issuance of HUD Notice 2021-34 (Expedited Regulatory Waivers for the Public Housing and Housing Choice Voucher [including Mainstream and Mod Rehab] Programs) affirmatively identified 227 rental market areas with significant rental market fluctuations and provided an expedited waiver process for PHAs to request an exception payment standard up to 120 percent of the FMRs but only through December 31, 2022. To develop a more permanent solution, the study team has concluded the following:

- The Department's FMR calculations would benefit from the use of real-time data sources and the improved FMR calculation methodology described in this study as an alternative to the existing CPI calculation. All three approaches to statistically identifying periods of rapidly rising rents—bandpass filter, cointegration, and rent-to-income ratios—are data-driven in their approach and provide insights into how various factors drive rental markets. After analyzing how each method compared across metropolitan areas, the band-pass filtering approach appeared to be the most robust and consistent for identifying when markets are experiencing extreme movements in price.
- The Department, by statue, has to produce and publish FMRs once a year. However, this study's alternative data sources and methods could also be used on a rolling basis for HUD approval of exception payment standards for PHAs' voucher programs and then incorporated into the formulation of the following years' FMRs. PIH Notice 2021-34 could serve as a template for implementation, as follows:

On a quarterly basis, the Department would determine eligible FMR areas with significant rental market fluctuations or rapidly rising rents by comparing alternative FMRs using this study's data sources, methods, and attendant recommendations by using private-sector data sources covering the FMR area(s), such as ApartmentList.com. Where use of the average private-sector rent data and study methodology demonstrate FMR increases at or above a certain percentage threshold (for example, 5 or 10 percent), the Department would deem those areas as "FMR Area Determined to Have Significant Rental Market Fluctuations," as one of its three criteria to meet for expedited exception payment standard waiver request submissions and evaluations. Using the Department's identical approach under PIH Notice 2021-34 with the study's alternative modifications would provide an immediate and possible rolling measure throughout each year of applicable FMRs that would be outside the "basic range" (90 through 110 percent of FMRs) and therefore justify expedited exception payment standard waiver submissions and review.

- These recommendations are consistent with Section 8(c)(1) of the U.S. Housing Act of 1937, which require HUD to calculate FMRs annually based "on the most recent available data" (42 USC 1437f).

Implementation

Alternative Final FMR *Increases* Would Take Effect upon Publication: Under the alternative FMR data sources and methods, all of the results of all FMR increases would take effect*,* including those with local CPI replacement data, upon publication. This recommendation conforms with the Department's existing regulatory and policy treatment of annual FMR increases, which would remain in place.

Alternative Final FMR *Decreases* of No More than 10 Percent Would Take Effect upon Publication: 24 CFR 888.113(b) limits decreases in the annual change in FMRs to no more than 10 percent. This regulatory treatment would remain in place under the alternative FMR.

Possible Areas for Further Study or Review

The Department could also study and possibly use a modified version of these alternative data sources and methods in place of not only the CPI factor but also the Recent Mover Adjustment Factor, ACS 5-year 2-Bedroom Adjusted Standard Quality Gross Rent Factor, and Trend Factor Type and Small Area FMR calculations.

Recent Mover Adjustment Factor

As previously noted, the ACS 1-year data are insufficient to capture rapidly rising rents compared with the more recent 12-month, 15-month, 18-month, or 24 month "recent mover" data from FMR reevaluations and appeals, which has been historically true before and after HUD's data sources and method rulemaking improvements over the past several years. The Department could compare and possibly replace the ACS 1-year data with data from the most recent 12-month, 15-month, or 18-month period available before its issuance of proposed FMRs, using the ApartmentList.com data or other similar sources.

ACS 5-Year Factor and Trend Factor

HUD contracted with 2M Research for a study titled *Deriving Local Trend Factors for Fair Market Rent Estimation,* which was published in March 2019 (2M Research, 2019). On the basis of the study's findings and HUD's rulemaking, some of the improvements were proposed[2] and later adopted, starting with the Department's FY 2020 FMRs.[3] As a result of the study's findings, HUD replaced the national trend factor with local and regional trend factors. HUD's replacement of its previous trend factor helped address current market conditions, including those in which rent prices are escalating rapidly.

The Phase II analysis of that report suggested that localization of trend factors is feasible and, in certain areas, may lead to more accurate trend factors and will improve the accuracy of FMRs. The Axiometrics data, although appealing, is based on a limited number of apartment sites, and the monthly series is relatively short. The ApartmentList.com monthly dataset, unlike Axiometrics data, is based on the universe of apartment units and is derived from real-time market conditions for rental contracts rather than a survey-based method like ACS data. The entire ApartmentList.com database also covers state,

[2] "Proposed Changes to the Methodology Used for Estimating Fair Market Rents." Published in the Federal Register as 84 Fed. Reg., 26141–26144.
[3] "Fair Market Rents for the Housing Choice Voucher Program, Moderate Rehabilitation Single Room Occupancy Program, and Other Programs Fiscal Year 2020." FR–6161–N–02. 2019-18608.pdf (govinfo.gov)

region, metro, and city-level geographies. The Department could further examine the potential of the ApartmentList.com database in improving predictions of FMR in metro areas.

Small Area FMRs (SAFMRs)

The study team is aware that outside the Census Bureau for ZIP Code Tabulation Areas (ZCTAs), the Department currently uses a considerable number of data sources and methods for formulation of FMRs, which are also used as components of the existing Small Area FMR (SAFMR) calculations. The Department may wish to consider where a methodology intersection exists between the FMRs and the SAFMRs and whether the ApartmentList.com and utility data alternatives employed in this study could be used for the existing FMR-based elements of the SAFMR calculations instead.

Appendix A: Model Estimations and Forecast Evaluations

Alaska

Vector Error Correction Estimates
Sample (adjusted): 1996Q3 2018Q4
Included observations: 90 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT_ALAS(-1))	1.000000		
LOG(RINCOME_ALAS...	-2.129231 (0.15490) [-13.7457]		
LOG(RHPRIC_ALAS(-1))	-0.346758 (0.11777) [-2.94444]		
C	6.578377		
R-squared	0.812884	0.481473	0.340851
Adj. R-squared	0.771873	0.367824	0.196380
Sum sq. resids	0.000344	0.003607	0.009076
S.E. equation	0.002172	0.007029	0.011150
F-statistic	19.82080	4.236469	2.359302
Log likelihood	433.6142	327.9090	286.3848
Akaike AIC	-9.258092	-6.909088	-5.986328
Schwarz SC	-8.785906	-6.436902	-5.514142
Mean dependent	0.006137	0.003899	0.003224
S.D. dependent	0.004547	0.008841	0.012438

Dependent Variable: D(RENT_ALAS)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q4
Included observations: 95
Convergence achieved after 27 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.900044	0.202201	4.451235	0.0000
AR(1)	1.311725	0.150824	8.697076	0.0000
AR(2)	-0.538509	0.146773	-3.668998	0.0004
MA(1)	0.389484	0.099862	3.900220	0.0002
MA(2)	-1.158313	0.113859	-10.17326	0.0000
MA(3)	0.203316	0.123914	1.640782	0.1045
MA(4)	0.803141	0.097149	8.267146	0.0000
SIGMASQ	0.092430	0.015466	5.976190	0.0000

R-squared	0.825842	Mean dependent var	0.931419
Adjusted R-squared	0.811829	S.D. dependent var	0.732372
S.E. of regression	0.317693	Akaike info criterion	0.716689
Sum squared resid	8.780834	Schwarz criterion	0.931752
Log likelihood	-26.04271	Hannan-Quinn criter.	0.803590
F-statistic	58.93506	Durbin-Watson stat	1.869544
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT_ALAS_A	45.55066	0.0066
RENT_ALAS_V	35.43657	0.0095

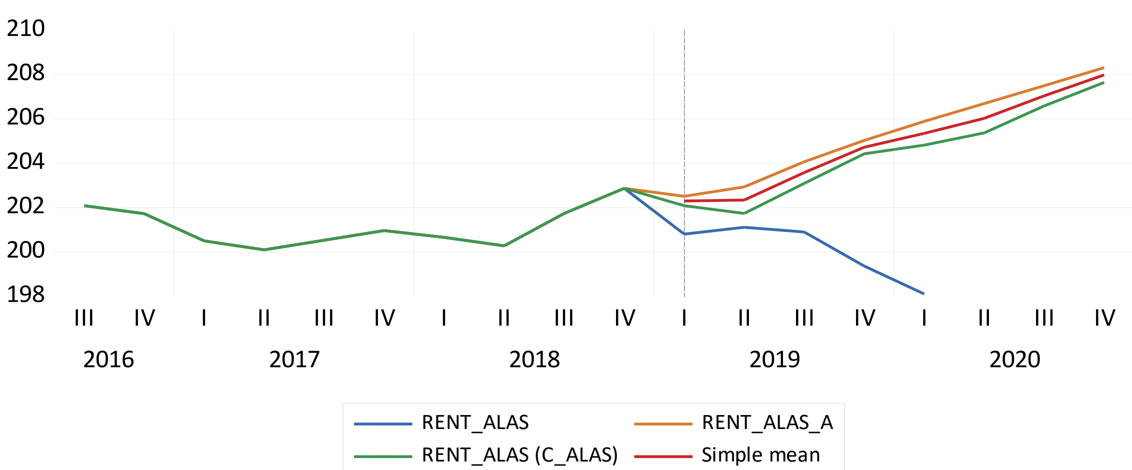
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	5.887818	0.0042	0.9979	0.0021
Sq Error	2.539083	0.0640	0.9680	0.0320

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT_ALAS_A	4.669243	4.030663	2.021409	1.994290	0.011553	5.108689
RENT_ALAS_V	3.936904	3.175732	1.594002	1.574667	0.009761	4.320455
Simple mean	4.294964	3.603197	1.807705	1.784726	0.010638	4.705738

Forecast Comparison Graph



Atlanta:

Vector Error Correction Estimates
Sample (adjusted): 1986Q1 2018Q4
Included observations: 81 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT ATL(-1))	1.000000		
LOG(RINCOME ATL(-1))	-2.058413 (0.16266) [-12.6543]		
LOG(RHPRICE ATL(-1))	-0.481410 (0.16689) [-2.88459]		
C	5.155842		
R-squared	0.606062	0.627844	0.699016
Adj. R-squared	0.456638	0.486681	0.584849
Sum sq. resids	0.003988	0.001378	0.007941
S.E. equation	0.008292	0.004874	0.011701
F-statistic	4.055975	4.447662	6.122771
Log likelihood	286.7812	329.8232	258.8897
Akaike AIC	-6.513115	-7.575881	-5.824438
Schwarz SC	-5.833210	-6.895976	-5.144532
Mean dependent	0.005767	0.002729	0.002212
S.D. dependent	0.011249	0.006803	0.018160

Dependent Variable: DLOG(RENT ATL)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 111
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.010705	0.003574	2.994922	0.0034
AR(1)	0.157395	0.092536	1.700909	0.0919
AR(2)	0.306839	0.067684	4.533385	0.0000
AR(3)	-0.082684	0.118316	-0.698843	0.4862
AR(4)	0.361024	0.081768	4.415251	0.0000
SIGMASQ	0.000115	1.28E-05	8.958149	0.0000

R-squared	0.364082	Mean dependent var	0.008900
Adjusted R-squared	0.333800	S.D. dependent var	0.013496
S.E. of regression	0.011016	Akaike info criterion	-6.105857
Sum squared resid	0.012742	Schwarz criterion	-5.959396
Log likelihood	344.8751	Hannan-Quinn criter.	-6.046442
F-statistic	12.02311	Durbin-Watson stat	1.915574

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

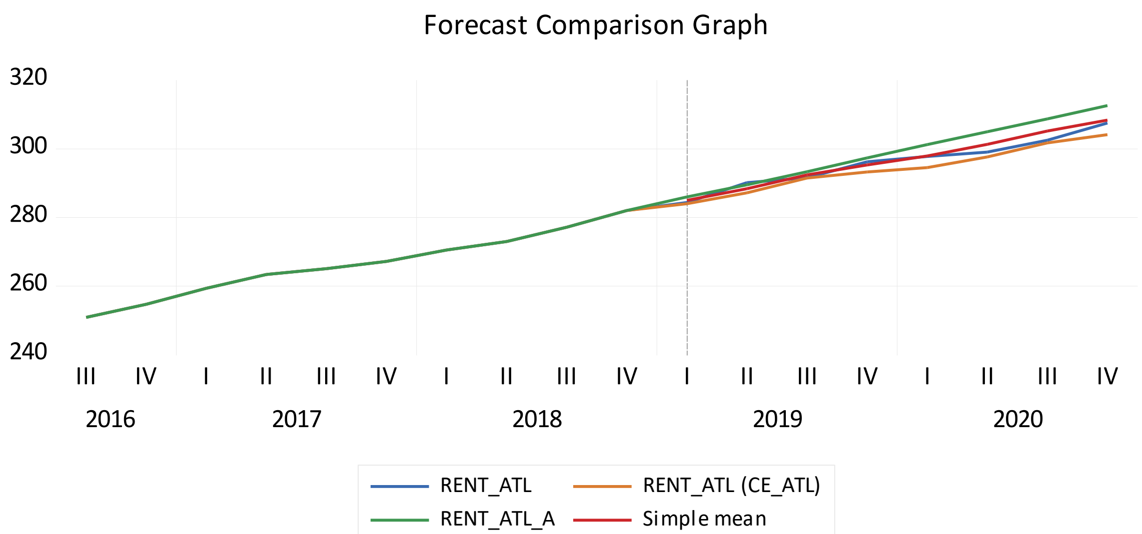
Forecast	F-stat	F-prob
RENT ATL V	0.631977	0.4569
RENT ATL A	13.74701	0.0100

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-1.374736	0.2116	0.1058	0.8942
Sq Error	-1.544491	0.1664	0.0832	0.9168

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT ATL V	2.293374	1.903201	0.638614	0.641581	0.003883	0.650854
RENT ATL A	3.854335	3.222705	1.075973	1.067915	0.006471	1.068486
Simple mean	1.508189	1.249091	0.420217	0.419526	0.002543	0.423210



Baltimore

Vector Error Correction Estimates
Sample (adjusted): 1999Q1 2018Q2
Included observations: 78 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(RENT_BAL(-1))	1.000000
LOG(RINCOME_BAL(-1))	-3.855242
	(0.33221)
	[-11.6048]
LOG(RHPRICE_BAL(-1))	0.199718
	(0.11674)
	[1.71077]
C	15.37901

R-squared	0.342677	0.236377	0.592870
Adj. R-squared	0.244569	0.122403	0.532105
Sum sq. resids	0.003036	0.002577	0.012742
S.E. equation	0.006732	0.006201	0.013790
F-statistic	3.492862	2.073962	9.756679
Log likelihood	285.3235	291.7260	229.3868
Akaike AIC	-7.033936	-7.198104	-5.599661
Schwarz SC	-6.701580	-6.865747	-5.267305
Mean dependent	0.009418	0.003064	0.003956
S.D. dependent	0.007745	0.006620	0.020160

Dependent Variable: DLOG(RENT BAL)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1998Q2 2018Q2
Included observations: 81
Convergence achieved after 6 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009454	0.000979	9.659102	0.0000
AR(1)	0.437531	0.093128	4.698174	0.0000
AR(2)	-0.461934	0.101065	-4.570666	0.0000
AR(3)	0.266164	0.102760	2.590150	0.0115
SIGMASQ	4.32E-05	7.55E-06	5.723120	0.0000

R-squared	0.246950	Mean dependent var	0.009458
Adjusted R-squared	0.207316	S.D. dependent var	0.007620
S.E. of regression	0.006784	Akaike info criterion	-7.081564
Sum squared resid	0.003498	Schwarz criterion	-6.933758
Log likelihood	291.8033	Hannan-Quinn criter.	-7.022262
F-statistic	6.230720	Durbin-Watson stat	1.944266
Prob(F-statistic)	0.000217		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT_BAL_A	91.21358	0.0002
RENT_BAL_V	192.9742	0.0000

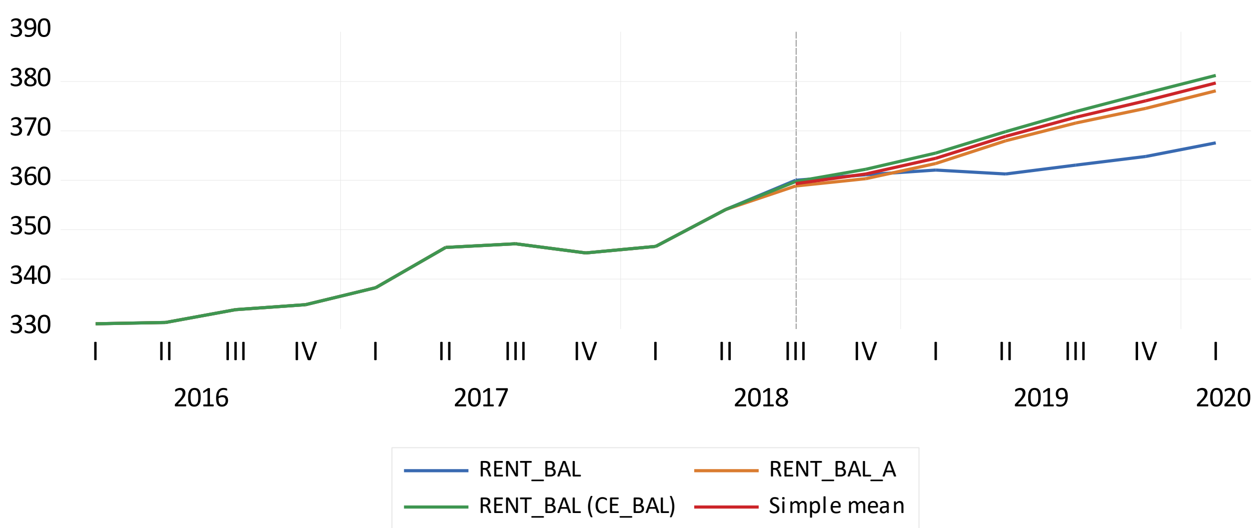
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-3.028704	0.0231	0.0116	0.9884
Sq Error	-2.720041	0.0346	0.0173	0.9827

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT_BAL_A	6.848337	5.545568	1.522629	1.505443	0.009373	4.438792
RENT_BAL_V	8.892730	7.229195	1.984691	1.955457	0.012134	5.775879
Simple mean	7.854543	6.276358	1.722911	1.700117	0.010734	5.098680

Forecast Comparison Graph



Boston:

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT_BOS(-1))	1.000000		
LOG(RINCOME_BOS(-1))	-1.744261 (0.06830) [-25.5387]		
LOG(RHPRICE_BOS(-1))	-0.307258 (0.05945) [-5.16823]		
C	4.144789		
R-squared	0.414463	0.663965	0.731082
Adj. R-squared	0.334390	0.618012	0.694307
Sum sq. resids	0.007198	0.002123	0.011364
S.E. equation	0.007843	0.004259	0.009855
F-statistic	5.176046	14.44864	19.87977
Log likelihood	468.5956	550.4132	437.9986
Akaike AIC	-6.740233	-7.961390	-6.283561
Schwarz SC	-6.372597	-7.593754	-5.915925
Mean dependent	0.008668	0.003975	0.003059
S.D. dependent	0.009614	0.006891	0.017825

Dependent Variable: DLOG(RENT BOS,2)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q3 2018Q4
Included observations: 154
Convergence achieved after 27 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.81E-05	0.000260	-0.376582	0.7070
AR(1)	-0.991263	0.006127	-161.7970	0.0000
MA(1)	-0.215759	0.082596	-2.612210	0.0099
MA(2)	-0.822241	0.071180	-11.55151	0.0000
MA(3)	0.368648	0.086144	4.279444	0.0000
MA(4)	0.304325	0.068415	4.448201	0.0000
SIGMASQ	9.06E-05	8.38E-06	10.80518	0.0000

R-squared	0.729970	Mean dependent var	9.21E-05
Adjusted R-squared	0.718949	S.D. dependent var	0.018377
S.E. of regression	0.009742	Akaike info criterion	-6.354506
Sum squared resid	0.013952	Schwarz criterion	-6.216462
Log likelihood	496.2969	Hannan-Quinn criter.	-6.298433
F-statistic	66.23078	Durbin-Watson stat	1.949906
Prob(F-statistic)	0.000000		

Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT BOS V	13.01435	0.0113
RENT BOS A	241.9841	0.0000

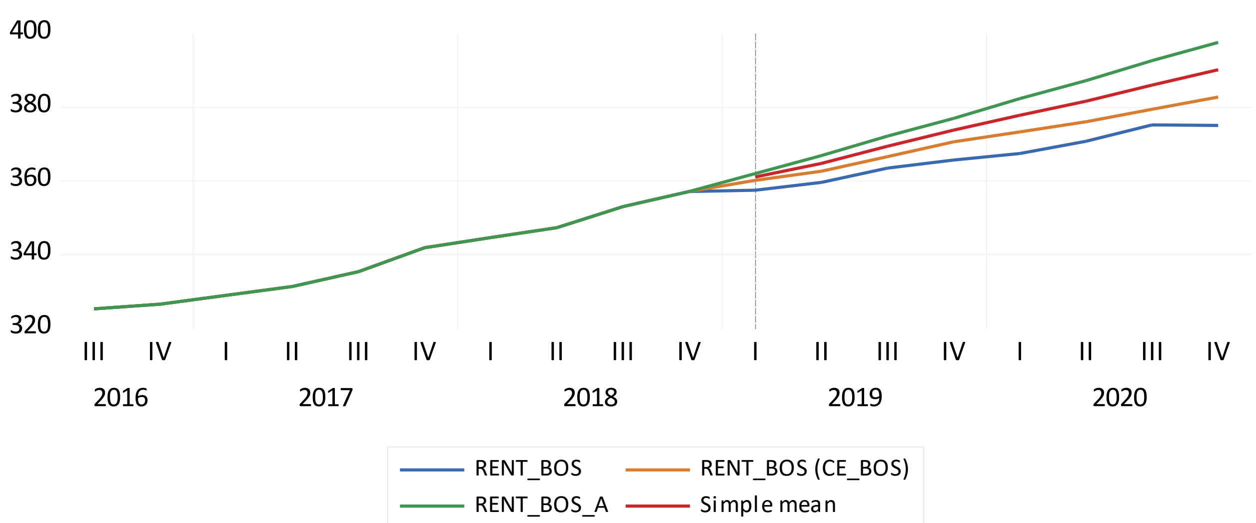
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-5.138722	0.0013	0.0007	0.9993
Sq Error	-3.329822	0.0126	0.0063	0.9937

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT BOS V	4.869779	4.603662	1.249625	1.241018	0.006594	1.750959
RENT BOS A	14.04020	12.87119	3.484416	3.414471	0.018799	5.099799
Simple mean	9.423546	8.737426	2.367020	2.335211	0.012689	3.415835

Forecast Comparison Graph



Dallas:

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT DAL(-1))	1.000000		
LOG(RINCOME DAL(-1))	-1.329742		
	(0.08388)		
	[-15.8532]		
LOG(RHPRICE DAL(-1))	-0.260749		
	(0.10913)		
	[-2.38942]		
C	1.691189		
R-squared	0.351637	0.554781	0.546328
Adj. R-squared	0.262971	0.493897	0.484287
Sum sq. resids	0.007238	0.004180	0.010596
S.E. equation	0.007865	0.005977	0.009516
F-statistic	3.965896	9.112018	8.805961
Log likelihood	468.2189	505.0012	442.6875
Akaike AIC	-6.734611	-7.283600	-6.353545
Schwarz SC	-6.366975	-6.915964	-5.985909
Mean dependent	0.006699	0.003810	0.001110
S.D. dependent	0.009162	0.008402	0.013252

Dependent Variable: DLOG(RENT DAL)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 155
Convergence achieved after 201 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008295	0.001639	5.059621	0.0000
AR(1)	-0.573466	0.076886	-7.458629	0.0000
AR(2)	0.773007	0.090216	8.568396	0.0000
AR(3)	-0.072509	0.099937	-0.725545	0.4693
AR(4)	-0.489949	0.093602	-5.234363	0.0000
MA(1)	0.530853	48.31357	0.010988	0.9912
MA(2)	-0.711802	84.00603	-0.008473	0.9933
MA(3)	0.530856	78.39426	0.006772	0.9946
MA(4)	0.999998	235.9915	0.004237	0.9966
SIGMASQ	0.000107	0.002106	0.050903	0.9595

R-squared	0.338699	Mean dependent var	0.008263
Adjusted R-squared	0.297653	S.D. dependent var	0.012775
S.E. of regression	0.010706	Akaike info criterion	-6.093756
Sum squared resid	0.016620	Schwarz criterion	-5.897406
Log likelihood	482.2661	Hannan-Quinn criter.	-6.014003
F-statistic	8.251634	Durbin-Watson stat	1.943366
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT DAL V	11.42477	0.0149
RENT DAL A	7.187462	0.0365

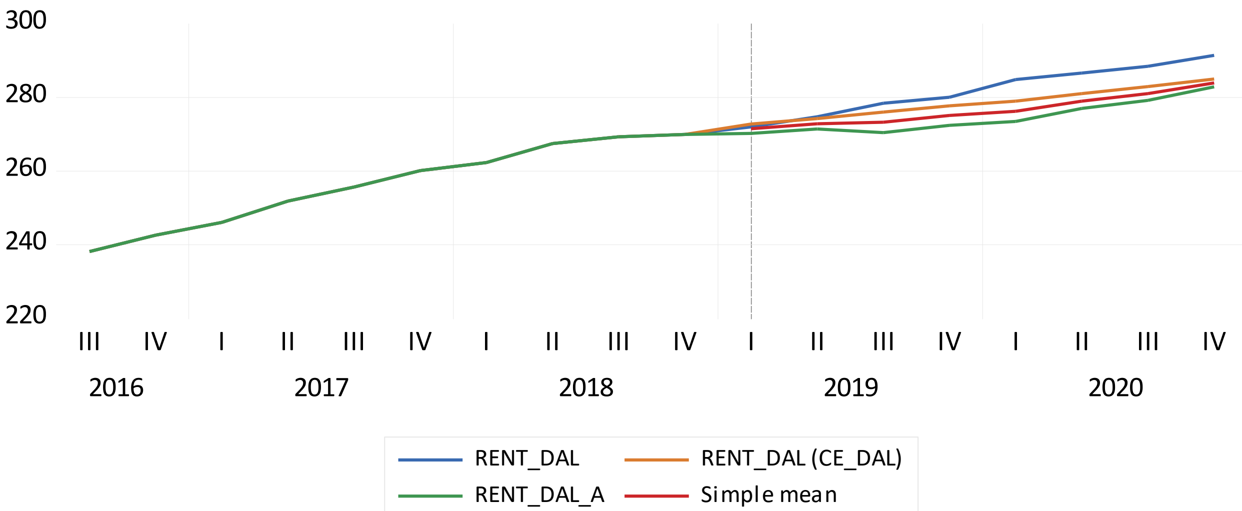
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-6.373901	0.0004	0.0002	0.9998
Sq Error	-4.346105	0.0034	0.0017	0.9983

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT DAL V	4.316429	3.674193	1.285603	1.296911	0.007697	1.521532
RENT_DAL_A	8.034022	7.437187	2.617630	2.658024	0.014429	2.851531

Forecast Comparison Graph



Denver:

Vector Error Correction Estimates
Sample (adjusted): 1986Q3 2018Q4
Included observations: 130 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT DEN(-1))	1.000000		
LOG(RINCOME DEN(-1))	-15.58382 (3.21545) [-4.84654]		
LOG(RHPRICE DEN(-1))	-9.732707 (1.67891) [-5.79704]		
C	-89.94895		
R-squared	0.889714	0.602447	0.585827
Adj. R-squared	0.874099	0.546157	0.527183
Sum sq. resids	0.000689	0.003947	0.010847
S.E. equation	0.002469	0.005910	0.009797
F-statistic	56.97578	10.70244	9.989555
Log likelihood	605.1720	491.6951	425.9795
Akaike AIC	-9.048800	-7.303002	-6.291992
Schwarz SC	-8.673814	-6.928017	-5.917007
Mean dependent	0.008261	0.003084	0.004643
S.D. dependent	0.006958	0.008772	0.014248

Dependent Variable: DLOG(RENT DEN)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1985Q1 2018Q4
Included observations: 136
Convergence achieved after 7 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008017	0.002302	3.482884	0.0007
AR(1)	0.738090	0.064495	11.44417	0.0000
AR(2)	0.276202	0.110113	2.508348	0.0134
AR(3)	0.129568	0.145331	0.891536	0.3743
AR(4)	-0.245824	0.080674	-3.047125	0.0028
SIGMASQ	7.17E-06	9.12E-07	7.862088	0.0000

R-squared	0.846009	Mean dependent var	0.008097
Adjusted R-squared	0.840087	S.D. dependent var	0.006850
S.E. of regression	0.002739	Akaike info criterion	-8.904165
Sum squared resid	0.000975	Schwarz criterion	-8.775666
Log likelihood	611.4832	Hannan-Quinn criter.	-8.851946
F-statistic	142.8416	Durbin-Watson stat	1.861394
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

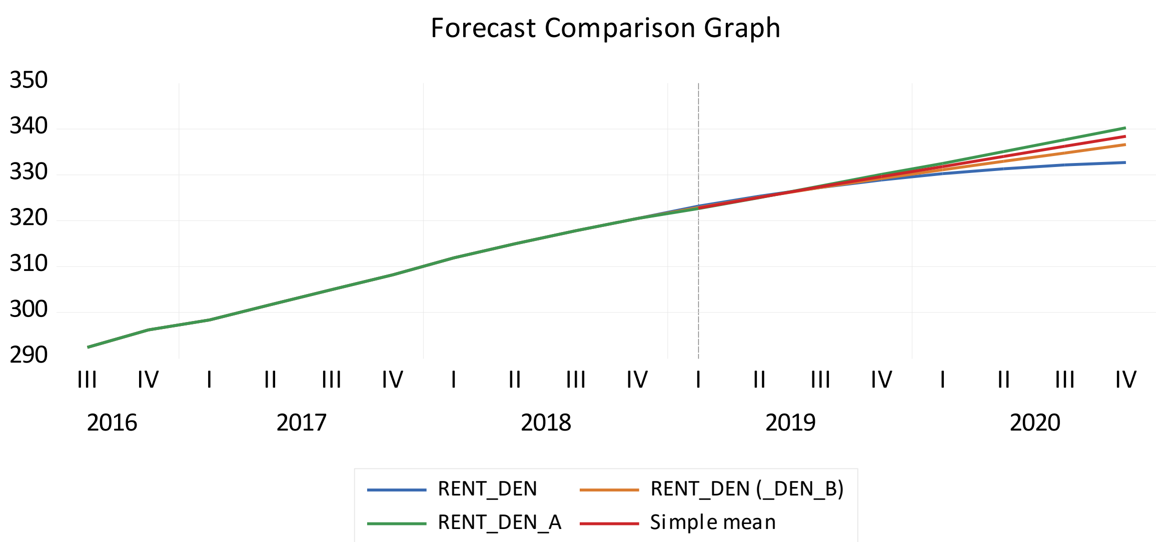
Forecast	F-stat	F-prob
RENT DEN V	51.56764	0.0004
RENT DEN A	67.83486	0.0002

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-3.082178	0.0178	0.0089	0.9911
Sq Error	-1.936651	0.0940	0.0470	0.9530

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT DEN V	1.794248	1.228874	0.370655	0.369219	0.002723	1.281357
RENT DEN A	3.695088	2.684212	0.809901	0.803815	0.005596	2.641441
Simple mean	2.741494	1.953213	0.589261	0.585907	0.004156	1.959104



Detroit:

Vector Error Correction Estimates
Sample (adjusted): 1985Q2 2018Q4
Included observations: 135 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT DET(-1))	1.000000		
LOG(RINCOME DET(-1))	-2.256159 (0.15762) [-14.3136]		
LOG(RHPRICE DET(-1))	0.436874 (0.08612) [5.07291]		
C	6.549442		
R-squared	0.260205	0.427976	0.639976
Adj. R-squared	0.180723	0.366519	0.601296
Sum sq. resids	0.006886	0.004151	0.018667
S.E. equation	0.007544	0.005857	0.012421
F-statistic	3.273758	6.963812	16.54532
Log likelihood	475.5816	509.7495	408.2651
Akaike AIC	-6.838246	-7.344437	-5.840964
Schwarz SC	-6.536958	-7.043149	-5.539676
Mean dependent	0.006519	0.003122	0.002980
S.D. dependent	0.008334	0.007359	0.019671

Dependent Variable: D(RENT DET)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 155
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.160387	0.153662	7.551576	0.0000
AR(1)	0.397697	0.189420	2.099556	0.0375
MA(1)	-0.433969	0.184955	-2.346349	0.0203
MA(2)	-0.016197	0.074543	-0.217278	0.8283
MA(3)	0.026373	0.083165	0.317117	0.7516
MA(4)	0.289696	0.086954	3.331615	0.0011
SIGMASQ	1.597729	0.178997	8.925998	0.0000

R-squared	0.094298	Mean dependent var	1.137845
Adjusted R-squared	0.057581	S.D. dependent var	1.332491
S.E. of regression	1.293560	Akaike info criterion	3.399959
Sum squared resid	247.6480	Schwarz criterion	3.537404
Log likelihood	-256.4968	Hannan-Quinn criter.	3.455786
F-statistic	2.568199	Durbin-Watson stat	1.986862
Prob(F-statistic)	0.021421		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

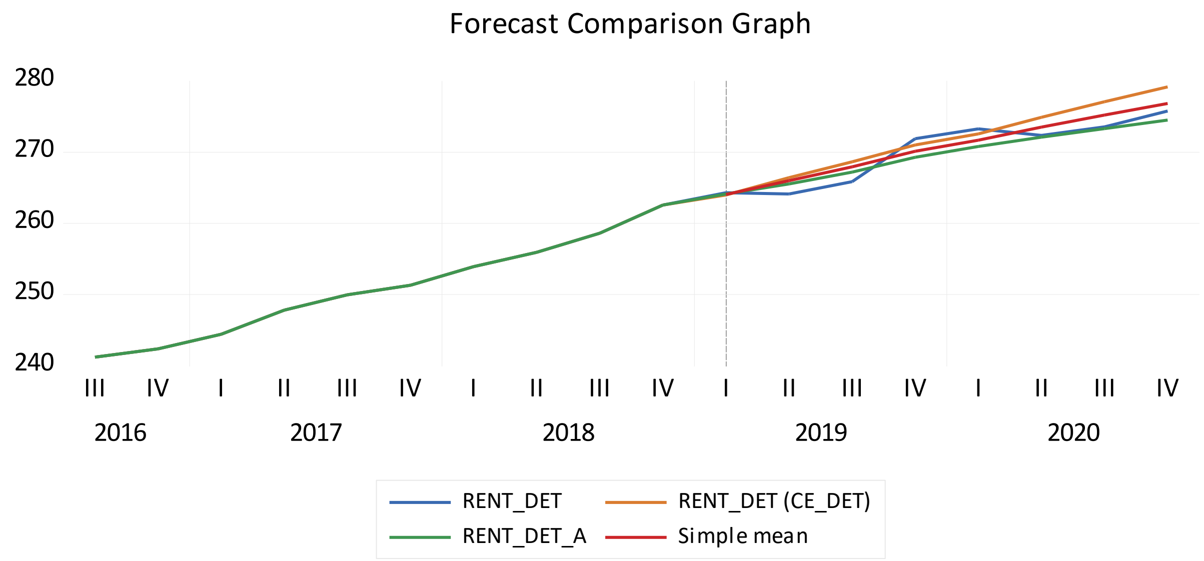
Forecast	F-stat	F-prob
RENT_DET_V	1.365324	0.2869
RENT_DET_A	1.115452	0.3316

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	1.260599	0.2478	0.8761	0.1239
Sq Error	1.354311	0.2177	0.8911	0.1089

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT_DET_V	2.363391	2.054555	0.758504	0.754967	0.004361	0.945846
RENT_DET_A	1.529954	1.227330	0.453382	0.454314	0.002834	0.617122
Simple mean	1.518163	1.417241	0.524598	0.523982	0.002807	0.612607



Honolulu:

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(RENT_HON(-1))	1.000000
LOG(RINCOME_HON(-1))	1.049293 (0.72604) [1.44524]
LOG(RHPRICE_HON(-1))	-1.876770 (0.28422) [-6.60319]
C	-11.52515

R-squared	0.905122	0.645925	0.601157
Adj. R-squared	0.892147	0.597505	0.546614
Sum sq. resids	0.000725	0.001501	0.023333
S.E. equation	0.002489	0.003581	0.014122
F-statistic	69.75989	13.33991	11.02177
Log likelihood	622.4117	573.6386	389.7952
Akaike AIC	-9.035996	-8.308039	-5.564108
Schwarz SC	-8.668360	-7.940403	-5.196471
Mean dependent	0.007993	0.002265	0.005850
S.D. dependent	0.007578	0.005645	0.020973

Dependent Variable: DLOG(RENT HON)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1984Q2 2018Q4
Included observations: 139
Convergence achieved after 125 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008051	0.003249	2.477711	0.0145
AR(1)	-0.084354	0.081930	-1.029589	0.3051
AR(2)	0.181659	0.099682	1.822375	0.0707
AR(3)	0.221055	0.122347	1.806789	0.0731
AR(4)	0.408591	0.073487	5.560037	0.0000
MA(1)	1.014108	4259.984	0.000238	0.9998
MA(2)	1.014106	6062.239	0.000167	0.9999
MA(3)	0.999995	10179.19	9.82E-05	0.9999
SIGMASQ	5.41E-06	0.011313	0.000478	0.9996

R-squared	0.902242	Mean dependent var	0.008115
Adjusted R-squared	0.896226	S.D. dependent var	0.007467
S.E. of regression	0.002406	Akaike info criterion	-9.078173
Sum squared resid	0.000752	Schwarz criterion	-8.888171
Log likelihood	639.9330	Hannan-Quinn criter.	-9.000961
F-statistic	149.9771	Durbin-Watson stat	2.073851
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

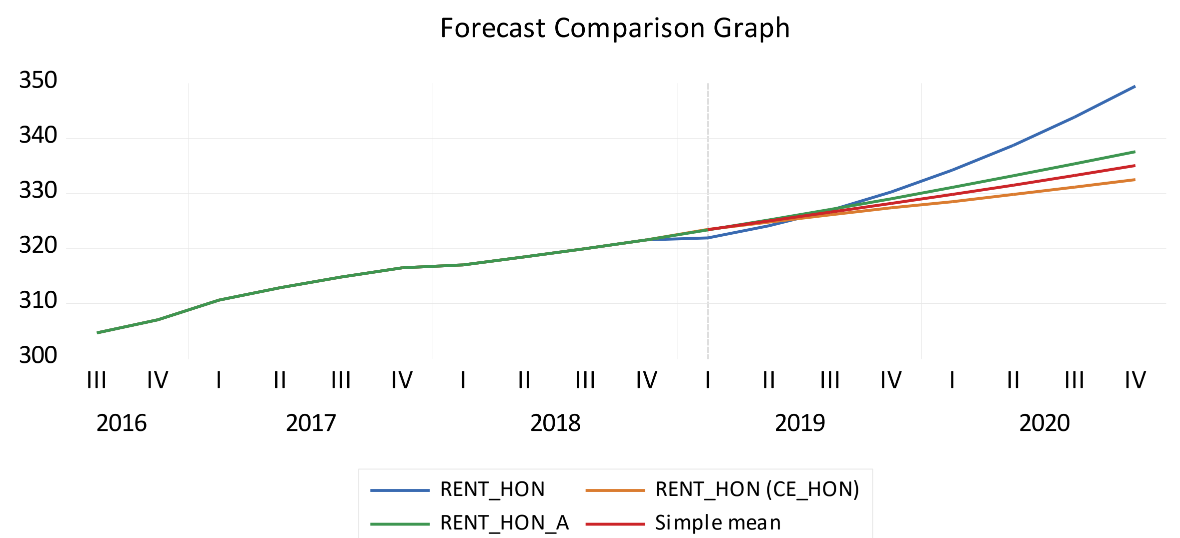
Forecast	F-stat	F-prob
RENT_HON_V	189.0363	0.0000
RENT_HON_A	88.51229	0.0001

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	3.066967	0.0181	0.9909	0.0091
Sq Error	2.078474	0.0763	0.9619	0.0381

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT_HON_V	8.474540	6.284118	1.839697	1.870125	0.012806	2.169584
RENT_HON_A	5.690673	4.122726	1.206450	1.219810	0.008569	1.451632
Simple mean	7.074495	5.184238	1.517205	1.538194	0.010672	1.808523



Houston:

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT_HOU(-1))	1.000000		
LOG(RINCOME_HOU(-1))	-1.456060		
	(0.20694)		
	[-7.03602]		
LOG(RHPRICE_HOU(-1))	-0.407013		
	(0.22286)		
	[-1.82628]		
C	2.442646		
R-squared	0.301219	0.493374	0.417036
Adj. R-squared	0.205659	0.424091	0.337314
Sum sq. resids	0.008649	0.005371	0.013216
S.E. equation	0.008598	0.006775	0.010628
F-statistic	3.152150	7.121213	5.231147
Log likelihood	456.2855	488.2124	427.8806
Akaike AIC	-6.556500	-7.033021	-6.132546
Schwarz SC	-6.188864	-6.665384	-5.764909
Mean dependent	0.007361	0.003822	0.001934
S.D. dependent	0.009647	0.008928	0.013056

Dependent Variable: DLOG(RENT HOU)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 155
Convergence achieved after 110 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007344	0.000423	17.36014	0.0000
AR(1)	0.447743	0.083229	5.379672	0.0000
AR(2)	1.308352	0.081999	15.95576	0.0000
AR(3)	-0.372238	0.093298	-3.989776	0.0001
AR(4)	-0.459069	0.089924	-5.105076	0.0000
MA(1)	-0.768534	73.33089	-0.010480	0.9917
MA(2)	-0.784085	14.45584	-0.054240	0.9568
MA(3)	0.768535	71.38801	0.010766	0.9914
MA(4)	-0.215915	32.38733	-0.006667	0.9947
SIGMASQ	0.000124	0.005287	0.023537	0.9813

R-squared	0.417957	Mean dependent var	0.007785
Adjusted R-squared	0.381830	S.D. dependent var	0.014669
S.E. of regression	0.011533	Akaike info criterion	-5.981302
Sum squared resid	0.019287	Schwarz criterion	-5.784952
Log likelihood	473.5509	Hannan-Quinn criter.	-5.901549
F-statistic	11.56917	Durbin-Watson stat	1.984925
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

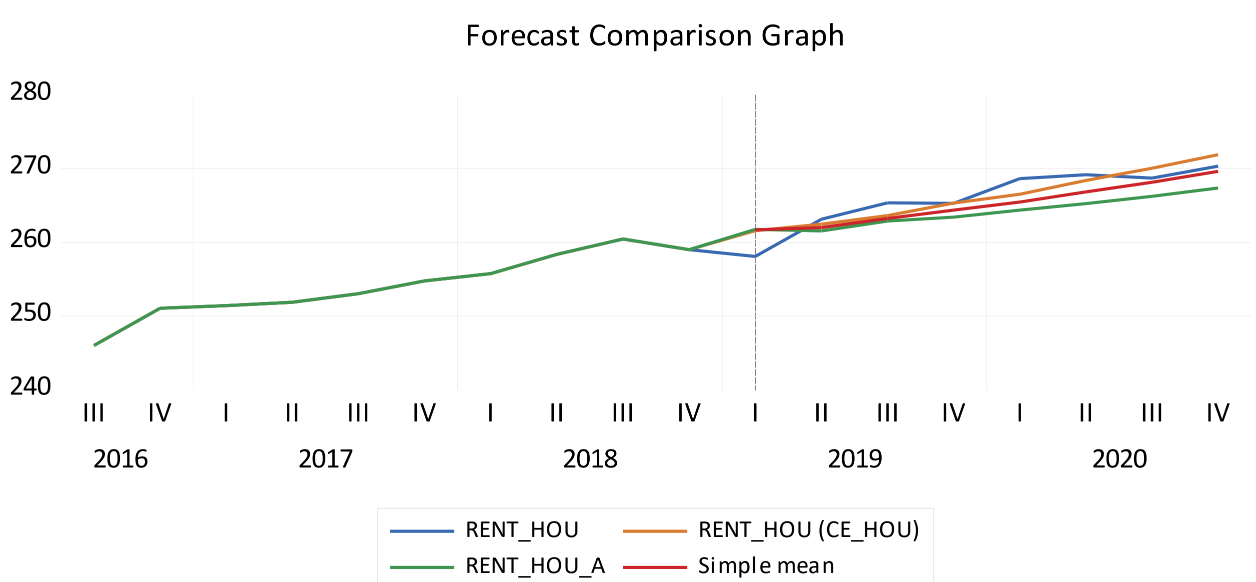
Forecast	F-stat	F-prob
RENT HOU V	0.035047	0.8577
RENT HOU A	3.582755	0.1072

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-4.399388	0.0032	0.0016	0.9984
Sq Error	-3.331562	0.0126	0.0063	0.9937

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT HOU V	1.766428	1.461466	0.551808	0.551046	0.003318	0.522468
RENT HOU A	3.042610	2.904132	1.090830	1.094861	0.005738	1.139875
Simple mean	2.118893	1.820610	0.686964	0.687777	0.003988	0.705700



Los Angeles:

Vector Error Correction Estimates
Sample (adjusted): 1996Q3 2018Q4
Included observations: 90 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT LA(-1))	1.000000		
LOG(RINOME LA(-1))	-2.355012		
	(0.24864)		
	[-9.47153]		
LOG(RHPRICE LA(-1))	-0.541792		
	(0.09780)		
	[-5.53952]		
C	6.745448		
R-squared	0.781346	0.636483	0.854440
Adj. R-squared	0.733422	0.556808	0.822537
Sum sq. resids	0.000504	0.002174	0.009349
S.E. equation	0.002627	0.005458	0.011317
F-statistic	16.30379	7.988506	26.78204
Log likelihood	416.5005	350.6825	285.0496
Akaike AIC	-8.877789	-7.415167	-5.956657
Schwarz SC	-8.405603	-6.942981	-5.484470
Mean dependent	0.009623	0.003279	0.006735
S.D. dependent	0.005087	0.008198	0.026864

Dependent Variable: D(RENT LA)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q4
Included observations: 95
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.421947	0.939463	2.578011	0.0116
AR(1)	0.750318	0.101620	7.383537	0.0000
AR(2)	-0.164550	0.120125	-1.369828	0.1741
AR(3)	0.349645	0.074262	4.708237	0.0000
SIGMASQ	0.538070	0.065622	8.199536	0.0000

R-squared	0.744516	Mean dependent var	2.288049
Adjusted R-squared	0.733161	S.D. dependent var	1.458933
S.E. of regression	0.753633	Akaike info criterion	2.344130
Sum squared resid	51.11664	Schwarz criterion	2.478545
Log likelihood	-106.3462	Hannan-Quinn criter.	2.398444
F-statistic	65.56817	Durbin-Watson stat	1.869976
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT LA A	0.077158	0.7992
RENT LA V	1.734135	0.2794

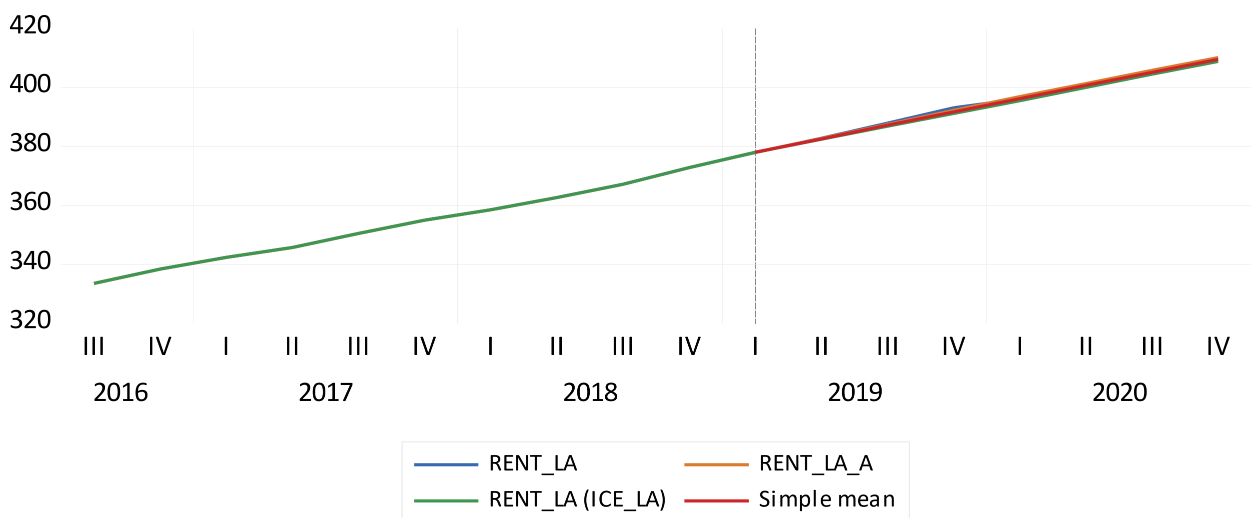
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-1.557231	0.1944	0.0972	0.9028
Sq Error	-1.265542	0.2744	0.1372	0.8628

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT LA A	0.545109	0.434799	0.110842	0.110861	0.000703	0.129611
RENT LA V	1.021389	0.788434	0.201651	0.201990	0.001319	0.244708
Simple mean	0.705732	0.495800	0.127008	0.127168	0.000911	0.169103

Forecast Comparison Graph



Miami:

Vector Error Correction Estimates
Sample (adjusted): 1985Q2 2018Q4
Included observations: 135 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT_MIA(-1))	1.000000		
LOG(RINCOME_MIA(-1))	-35.78269 (8.12411) [-4.40451]		
LOG(RHPRICE_MIA(-1))	11.70248 (2.78813) [4.19725]		
C	180.0218		
R-squared	0.296012	0.447379	0.599627
Adj. R-squared	0.220377	0.388006	0.556612
Sum sq. resids	0.009421	0.005404	0.043530
S.E. equation	0.008824	0.006683	0.018967
F-statistic	3.913687	7.535116	13.93988
Log likelihood	454.4272	491.9360	351.1143
Akaike AIC	-6.524847	-7.080533	-4.994286
Schwarz SC	-6.223560	-6.779245	-4.692998
Mean dependent	0.008315	0.002507	0.004676
S.D. dependent	0.009993	0.008543	0.028485

Dependent Variable: DLOG(RENT MIA)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 155
Convergence achieved after 16 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009370	0.002086	4.493001	0.0000
AR(1)	0.799589	0.090253	8.859445	0.0000
MA(1)	-0.839504	0.106634	-7.872791	0.0000
MA(2)	0.070826	0.061759	1.146817	0.2533
MA(3)	0.179782	0.071714	2.506947	0.0133
SIGMASQ	0.000132	8.44E-06	15.59602	0.0000

R-squared	0.089350	Mean dependent var	0.008914
Adjusted R-squared	0.058792	S.D. dependent var	0.012062
S.E. of regression	0.011702	Akaike info criterion	-6.017403
Sum squared resid	0.020405	Schwarz criterion	-5.899593
Log likelihood	472.3487	Hannan-Quinn criter.	-5.969551
F-statistic	2.923894	Durbin-Watson stat	1.964227
Prob(F-statistic)	0.015080		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

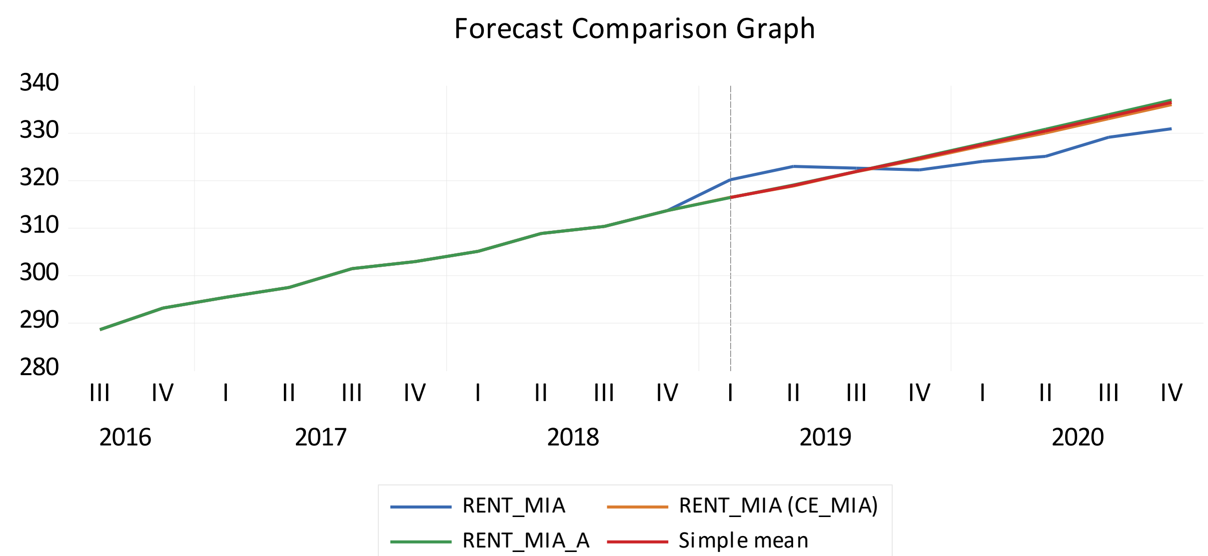
Forecast	F-stat	F-prob
RENT MIA V	39.36325	0.0008
RENT MIA A	48.99126	0.0004

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-2.703067	0.0305	0.0153	0.9847
Sq Error	-2.410766	0.0467	0.0234	0.9766

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT MIA V	3.758380	3.505322	1.077397	1.074559	0.005775	1.759710
RENT MIA A	4.237616	3.917749	1.203371	1.198648	0.006507	2.006509
Simple mean	3.994764	3.711535	1.140384	1.136640	0.006136	1.881696



Minneapolis:

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

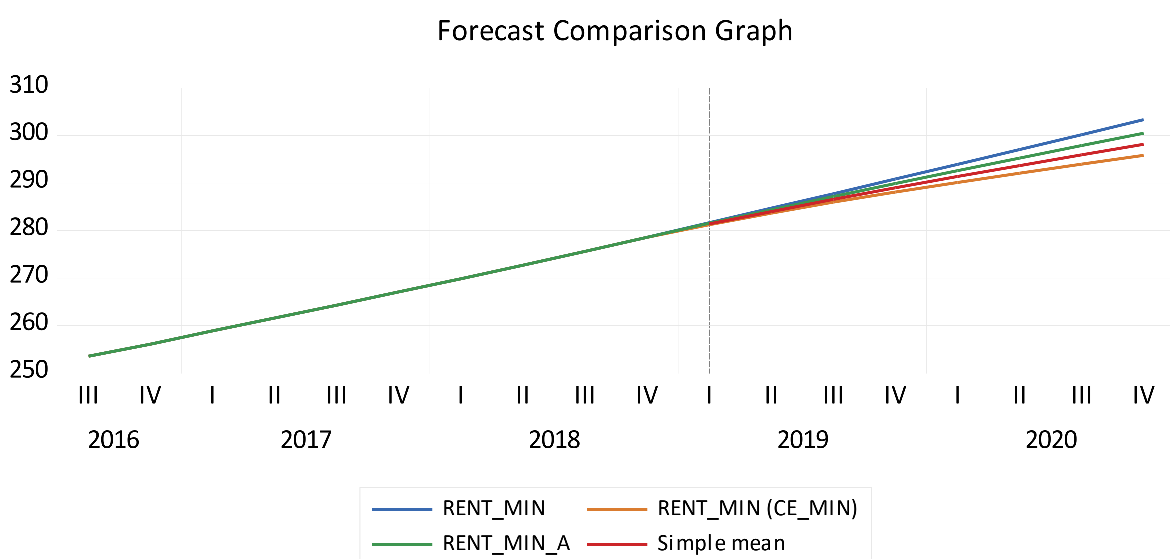
Forecast	F-stat	F-prob
RENT MIN V	330.5244	0.0000
RENT MIN A	159.4966	0.0000

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	4.176599	0.0042	0.9979	0.0021
Sq Error	2.562384	0.0374	0.9813	0.0187

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT MIN V	4.285384	3.575609	1.203962	1.214316	0.007371	1.450153
RENT MIN A	1.585515	1.293454	0.435035	0.436441	0.002716	0.536292
Simple mean	2.935069	2.434532	0.819499	0.824338	0.005038	0.993115



New York/New Jersey:

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT NYNJ(-1))	1.000000		
LOG(RINCOME NYNJ(-1))	0.392171		
	(0.57711)		
	[0.67954]		
LOG(RHPRICE NYNJ(-1))	-1.828266		
	(0.31379)		
	[-5.82649]		
C	-7.791747		
R-squared	0.417357	0.589082	0.750705
Adj. R-squared	0.337680	0.532888	0.716613
Sum sq. resids	0.002163	0.003078	0.011981
S.E. equation	0.004299	0.005129	0.010119
F-statistic	5.238071	10.48304	22.02022
Log likelihood	549.1550	525.5001	434.4565
Akaike AIC	-7.942613	-7.589554	-6.230694
Schwarz SC	-7.574976	-7.221917	-5.863057
Mean dependent	0.009455	0.003703	0.003860
S.D. dependent	0.005283	0.007505	0.019009

Dependent Variable: DLOG(RENT NYNJ,2)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q3 2018Q4
Included observations: 154
Convergence achieved after 104 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8.67E-05	7.70E-05	-1.125675	0.2622
AR(1)	-1.289865	0.163804	-7.874417	0.0000
AR(2)	-1.512411	0.084962	-17.80104	0.0000
AR(3)	-1.133690	0.164383	-6.896615	0.0000
AR(4)	-0.331509	0.076088	-4.356920	0.0000
MA(1)	0.311377	4.926920	0.063199	0.9497
MA(2)	0.383120	1.288210	0.297405	0.7666
MA(3)	-0.165582	10.62494	-0.015584	0.9876
MA(4)	-0.621946	48.84732	-0.012732	0.9899
SIGMASQ	2.16E-05	0.000366	0.058976	0.9531

R-squared	0.582294	Mean dependent var	-3.09E-05
Adjusted R-squared	0.556187	S.D. dependent var	0.007216
S.E. of regression	0.004807	Akaike info criterion	-7.729155
Sum squared resid	0.003328	Schwarz criterion	-7.531951
Log likelihood	605.1450	Hannan-Quinn criter.	-7.649051
F-statistic	22.30444	Durbin-Watson stat	1.971309
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

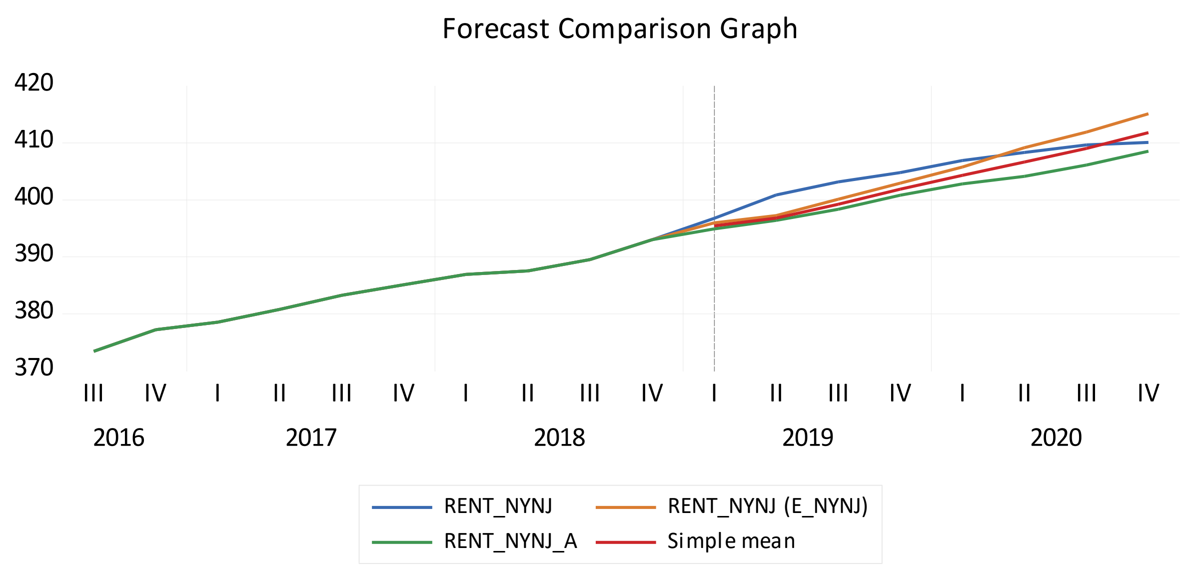
Forecast	F-stat	F-prob
RENT NYNJ V	14.28053	0.0092
RENT NYNJ A	0.456994	0.5242

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-1.676192	0.1376	0.0688	0.9312
Sq Error	-1.456012	0.1887	0.0944	0.9056

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT NYNJ V	2.709068	2.319197	0.571646	0.571583	0.003345	1.306948
RENT NYNJ A	3.733015	3.558492	0.878472	0.882741	0.004628	1.789140
Simple mean	2.624613	2.358847	0.583448	0.585350	0.003247	1.263116



Philadelphia:

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT_PHIL(-1))	1.000000		
LOG(RINCOME_PHIL(-1))	0.025402		
	(0.34760)		
	[0.07308]		
LOG(RHPRICE_PHIL(-1))	-1.320528		
	(0.22906)		
	[-5.76500]		
C	-5.737019		
R-squared	0.286564	0.422485	0.646676
Adj. R-squared	0.189000	0.343508	0.598358
Sum sq. resids	0.004423	0.002382	0.011071
S.E. equation	0.006149	0.004512	0.009727
F-statistic	2.937189	5.349500	13.38380
Log likelihood	501.2142	542.6843	439.7483
Akaike AIC	-7.227078	-7.846035	-6.309676
Schwarz SC	-6.859441	-7.478398	-5.942040
Mean dependent	0.007319	0.004015	0.004516
S.D. dependent	0.006828	0.005569	0.015349

Dependent Variable: D(RENT PHIL)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 155
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.489867	0.161318	9.235568	0.0000
AR(1)	0.778739	0.136596	5.701055	0.0000
MA(1)	-0.798758	0.150917	-5.292710	0.0000
MA(2)	0.003370	0.100966	0.033377	0.9734
MA(3)	0.169894	0.077528	2.191384	0.0300
SIGMASQ	1.295261	0.140612	9.211588	0.0000

R-squared	0.068077	Mean dependent var	1.478161
Adjusted R-squared	0.036804	S.D. dependent var	1.182753
S.E. of regression	1.160784	Akaike info criterion	3.175560
Sum squared resid	200.7655	Schwarz criterion	3.293370
Log likelihood	-240.1059	Hannan-Quinn criter.	3.223412
F-statistic	2.176887	Durbin-Watson stat	1.997017
Prob(F-statistic)	0.059686		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

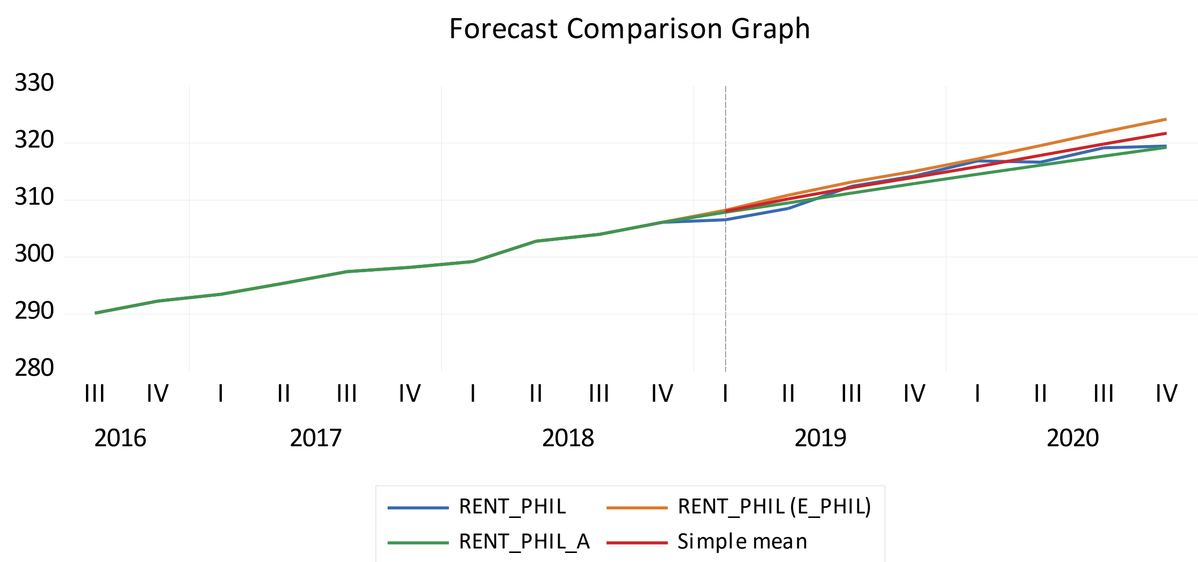
Forecast	F-stat	F-prob
RENT PHIL V	3.057870	0.1309
RENT PHIL A	2.015179	0.2055

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	1.241974	0.2542	0.8729	0.1271
Sq Error	1.447297	0.1911	0.9045	0.0955

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT PHIL V	2.456461	2.048350	0.649652	0.646659	0.003895	1.109222
RENT PHIL A	1.312898	1.167195	0.371817	0.372333	0.002091	0.577155
Simple mean	1.281053	1.096966	0.349287	0.348597	0.002036	0.545302



Phoenix:

Vector Error Correction Estimates
Sample (adjusted): 2003Q3 2018Q4
Included observations: 62 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(RENT_PHO(-1))	1.000000
LOG(RINCOME_PHO(-1))	-3.628374
	(0.40974)
	[-8.85527]
LOG(RHPRICE_PHO(-1))	0.202112
	(0.08345)
	[2.42206]
C	15.79268

R-squared	0.861498	0.859337	0.797430
Adj. R-squared	0.812253	0.809324	0.725404
Sum sq. resids	0.000615	0.000478	0.019223
S.E. equation	0.003697	0.003259	0.020668
F-statistic	17.49407	17.18213	11.07156
Log likelihood	269.1688	276.9944	162.4676
Akaike AIC	-8.134479	-8.386915	-4.692502
Schwarz SC	-7.551232	-7.803669	-4.109256
Mean dependent	0.006890	0.002729	0.004392
S.D. dependent	0.008533	0.007463	0.039442

Dependent Variable: DLOG(RENT PHO)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 2002Q2 2018Q4
Included observations: 67
Convergence achieved after 188 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006621	0.003003	2.204430	0.0315
AR(1)	-0.013174	0.237583	-0.055448	0.9560
AR(2)	1.531069	0.225275	6.796435	0.0000
AR(3)	0.007311	0.175782	0.041593	0.9670
AR(4)	-0.727335	0.169929	-4.280232	0.0001
MA(1)	0.896063	269.9761	0.003319	0.9974
MA(2)	-0.859583	34.70091	-0.024771	0.9803
MA(3)	-0.454618	185.9386	-0.002445	0.9981
MA(4)	0.321705	51.22167	0.006281	0.9950
SIGMASQ	1.28E-05	0.003874	0.003294	0.9974

R-squared	0.810527	Mean dependent var	0.006602
Adjusted R-squared	0.780610	S.D. dependent var	0.008268
S.E. of regression	0.003873	Akaike info criterion	-8.027725
Sum squared resid	0.000855	Schwarz criterion	-7.698666
Log likelihood	278.9288	Hannan-Quinn criter.	-7.897515
F-statistic	27.09265	Durbin-Watson stat	1.933690
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

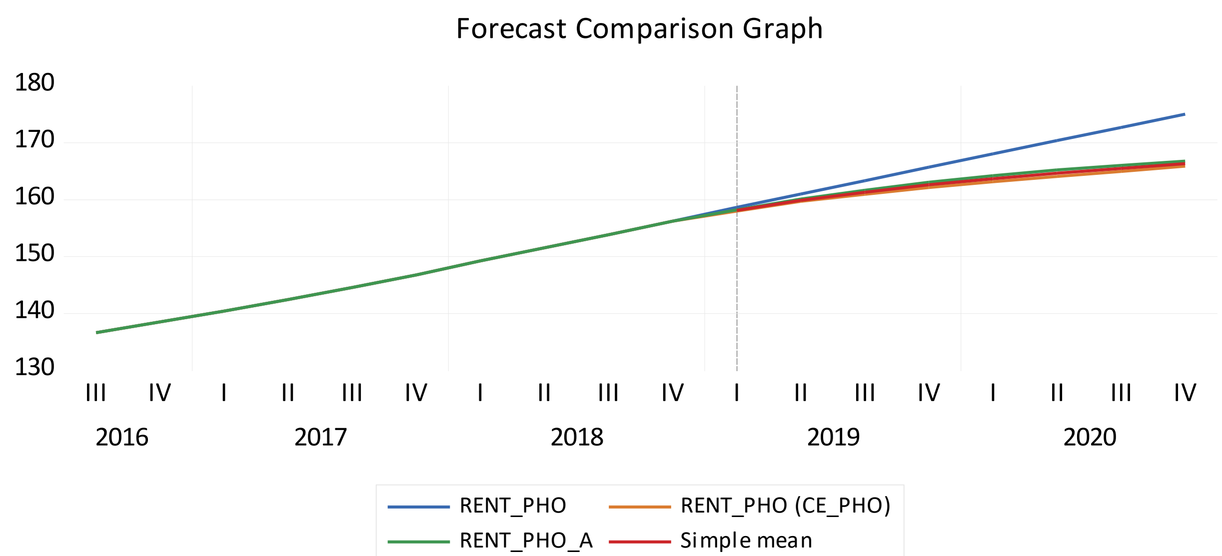
Forecast	F-stat	F-prob
RENT PHO V	91.63344	0.0001
RENT PHO A	76.73806	0.0001

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	6.815671	0.0002	0.9999	0.0001
Sq Error	3.560322	0.0092	0.9954	0.0046

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT PHO V	5.320176	4.486780	2.636932	2.685884	0.016154	2.369397
RENT PHO A	4.533593	3.689891	2.163748	2.199035	0.013732	2.014631
Simple mean	4.924042	4.088336	2.400340	2.442126	0.014933	2.190722



San Diego:

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT_SD(-1))	1.000000		
LOG(RINCOME_SD(-1))	-1.978266 (0.42111) [-4.69777]		
LOG(RHPRICE_SD(-1))	-0.827885 (0.16300) [-5.07918]		
C	4.717653		
R-squared	0.897975	0.704714	0.719358
Adj. R-squared	0.884023	0.664333	0.680980
Sum sq. resids	0.000499	0.001884	0.021038
S.E. equation	0.002065	0.004013	0.013409
F-statistic	64.36137	17.45159	18.74387
Log likelihood	647.4333	558.3943	396.7339
Akaike AIC	-9.409453	-8.080511	-5.667670
Schwarz SC	-9.041816	-7.712875	-5.300033
Mean dependent	0.008864	0.002754	0.005044
S.D. dependent	0.006063	0.006926	0.023741

Dependent Variable: DLOG(RENT SD)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1984Q2 2018Q4
Included observations: 139
Convergence achieved after 70 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.013278	0.004824	2.752607	0.0068
AR(1)	-0.055778	0.110871	-0.503091	0.6158
AR(2)	0.232885	0.142283	1.636771	0.1041
AR(3)	0.205072	0.151577	1.352926	0.1784
AR(4)	0.519034	0.104961	4.945005	0.0000
MA(1)	1.015962	0.068730	14.78201	0.0000
MA(2)	0.953494	0.085305	11.17741	0.0000
MA(3)	0.918176	0.068666	13.37161	0.0000
SIGMASQ	3.92E-06	5.82E-07	6.738452	0.0000

R-squared	0.918461	Mean dependent var	0.009549
Adjusted R-squared	0.913443	S.D. dependent var	0.006962
S.E. of regression	0.002048	Akaike info criterion	-9.436936
Sum squared resid	0.000545	Schwarz criterion	-9.246934
Log likelihood	664.8671	Hannan-Quinn criter.	-9.359725
F-statistic	183.0413	Durbin-Watson stat	2.087989
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

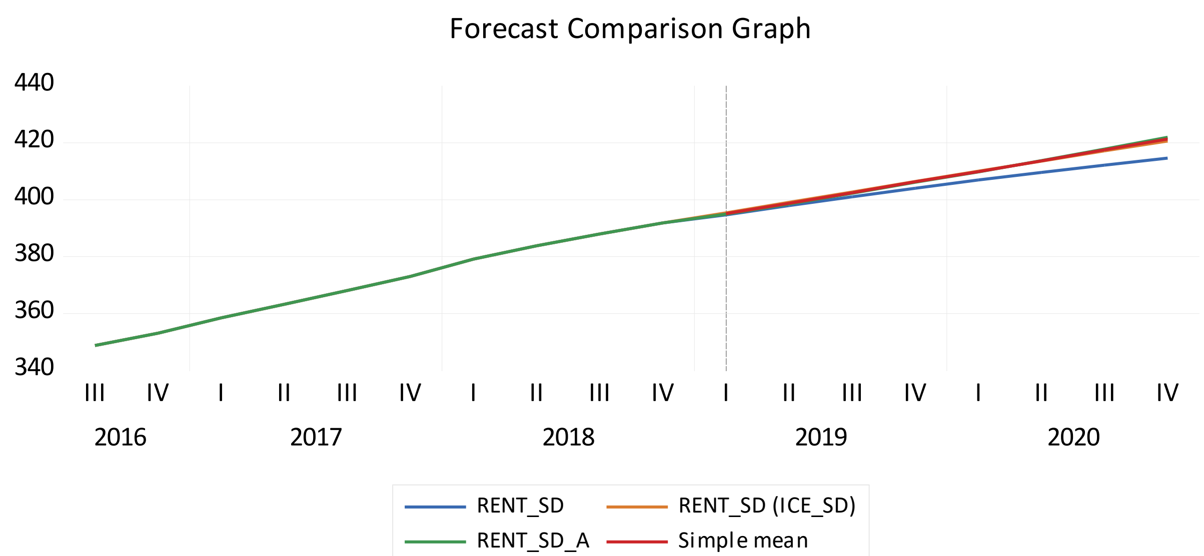
Forecast	F-stat	F-prob
RENT SD V	320.9701	0.0000
RENT SD A	114.2780	0.0000

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-0.148850	0.8859	0.4429	0.5571
Sq Error	-1.135714	0.2935	0.1467	0.8533

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT SD V	3.475661	2.990817	0.731529	0.727975	0.004273	1.273499
RENT SD A	3.843126	3.025501	0.737903	0.733583	0.004725	1.408788
Simple mean	3.650973	3.008159	0.734716	0.730807	0.004489	1.338424



Seattle

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 85 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(RENT SEA(-1))	1.000000
LOG(RINCOME SEA(-1))	-16.92373 (5.78918) [-2.92334]
LOG(RHPRICE SEA(-1))	-7.304502 (1.95219) [-3.74170]
C	-93.81802

R-squared	0.538868	0.682704	0.812632
Adj. R-squared	0.430366	0.608046	0.768545
Sum sq. resids	0.003481	0.003196	0.005928
S.E. equation	0.007155	0.006856	0.009336
F-statistic	4.966445	9.144433	18.43264
Log likelihood	308.7745	312.4013	286.1489
Akaike AIC	-6.865281	-6.950620	-6.332915
Schwarz SC	-6.376751	-6.462089	-5.844385
Mean dependent	0.009422	0.000150	0.003238
S.D. dependent	0.009479	0.010950	0.019407

Dependent Variable: DLOG(RENT SEA)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 111
Convergence achieved after 120 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008773	0.001060	8.277006	0.0000
AR(1)	1.668273	0.123663	13.49046	0.0000
AR(2)	-0.707599	0.126015	-5.615204	0.0000
MA(1)	-1.487387	67.39254	-0.022070	0.9824
MA(2)	0.401524	35.52413	0.011303	0.9910
MA(3)	0.588418	62.58543	0.009402	0.9925
MA(4)	-0.502553	77.68049	-0.006469	0.9949
SIGMASQ	5.39E-05	0.000852	0.063310	0.9496

R-squared	0.366918	Mean dependent var	0.009252
Adjusted R-squared	0.323893	S.D. dependent var	0.009272
S.E. of regression	0.007624	Akaike info criterion	-6.796313
Sum squared resid	0.005987	Schwarz criterion	-6.601031
Log likelihood	385.1954	Hannan-Quinn criter.	-6.717093
F-statistic	8.528020	Durbin-Watson stat	1.958949
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT SEA V	2.981810	0.1350
RENT SEA A	47.53959	0.0005

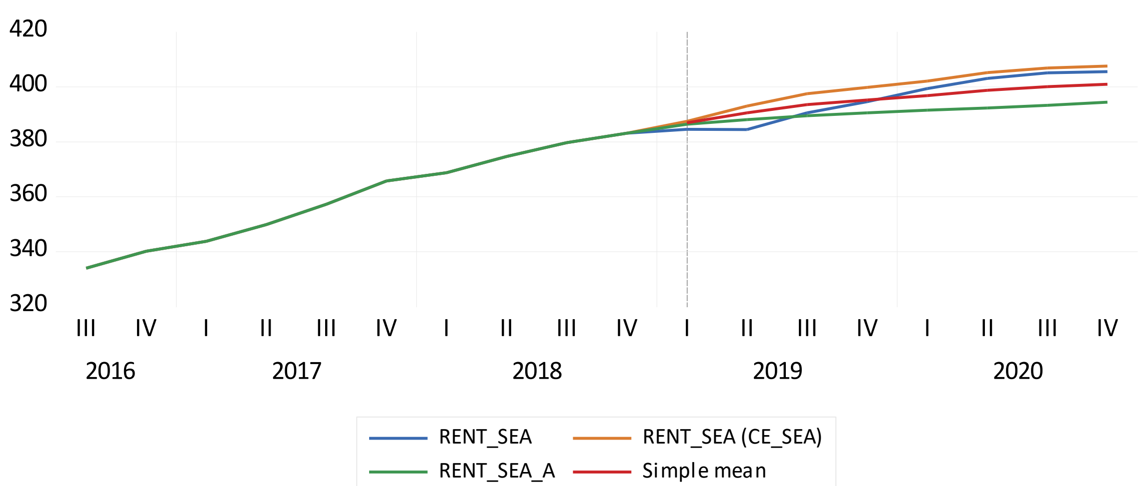
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-1.076023	0.3176	0.1588	0.8412
Sq Error	-1.349561	0.2192	0.1096	0.8904

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT SEA V	4.686035	4.024815	1.026110	1.018936	0.005887	1.347080
RENT SEA A	7.706430	6.507417	1.624531	1.641678	0.009795	2.185628
Simple mean	3.920964	3.556351	0.897354	0.897935	0.004954	1.106458

Forecast Comparison Graph



San Francisco

Vector Error Correction Estimates
Sample (adjusted): 1985Q3 2018Q4
Included observations: 134 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(RENT_SF(-1))	1.000000
LOG(RINCOME_SF(-1))	7.985885 (2.64190) [3.02278]
LOG(RHPRICE_SF(-1))	-4.472673 (0.97387) [-4.59269]
C	-47.18365

R-squared	0.525702	0.605147	0.707362
Adj. R-squared	0.460841	0.551151	0.667343
Sum sq. resids	0.004015	0.002836	0.020791
S.E. equation	0.005858	0.004923	0.013330
F-statistic	8.105035	11.20707	17.67573
Log likelihood	507.6990	530.9945	397.5240
Akaike AIC	-7.323866	-7.671560	-5.679462
Schwarz SC	-6.956230	-7.303923	-5.311826
Mean dependent	0.010061	0.002759	0.008252
S.D. dependent	0.007978	0.007349	0.023113

Dependent Variable: DLOG(RENT SF)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1980Q2 2018Q4
Included observations: 155
Convergence achieved after 38 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.012809	0.003215	3.983885	0.0001
AR(1)	-0.935974	0.049661	-18.84724	0.0000
AR(2)	0.774095	0.077463	9.993053	0.0000
AR(3)	0.883429	0.041269	21.40647	0.0000
MA(1)	1.213180	0.096866	12.52434	0.0000
MA(2)	-0.185834	0.159727	-1.163448	0.2465
MA(3)	-0.461350	0.094611	-4.876273	0.0000
SIGMASQ	4.93E-05	5.17E-06	9.547453	0.0000

R-squared	0.481889	Mean dependent var	0.011788
Adjusted R-squared	0.457217	S.D. dependent var	0.009791
S.E. of regression	0.007213	Akaike info criterion	-6.955814
Sum squared resid	0.007649	Schwarz criterion	-6.798734
Log likelihood	547.0756	Hannan-Quinn criter.	-6.892012
F-statistic	19.53182	Durbin-Watson stat	1.941783
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT_SF_V	19.25504	0.0046
RENT_SF_A	27.76010	0.0019

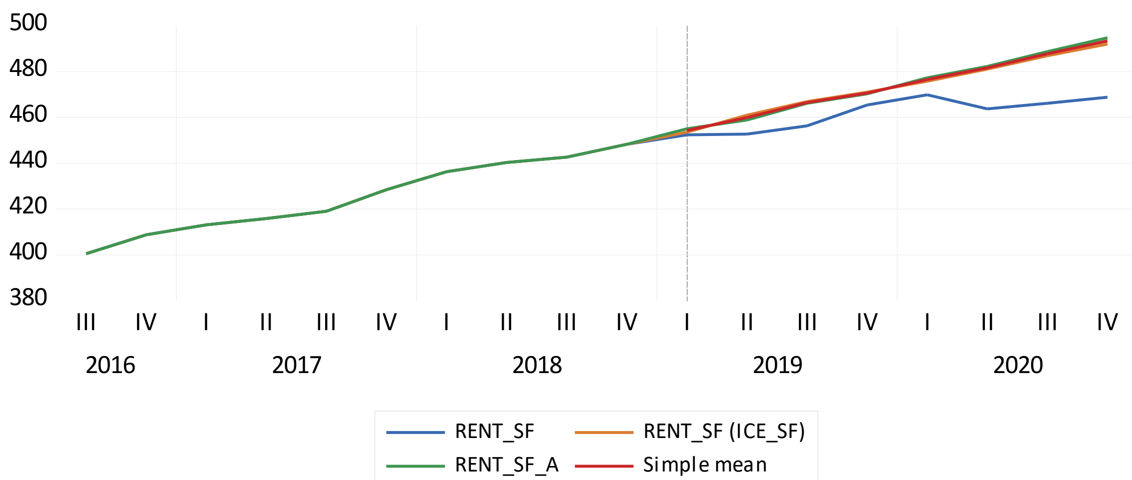
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-1.148249	0.2886	0.1443	0.8557
Sq Error	-1.493222	0.1790	0.0895	0.9105

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT_SF_V	13.75523	11.58199	2.495962	2.453135	0.014701	2.990321
RENT_SF_A	14.75520	12.23688	2.635007	2.585960	0.015758	3.198584
Simple mean	14.24024	11.90944	2.565484	2.519698	0.015214	3.091501

Forecast Comparison Graph



St. Louis

Vector Error Correction Estimates
Sample (adjusted): 1996Q4 2018Q4
Included observations: 89 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(RENT STLOUIS(-1))	1.000000
LOG(RINCOME STL(-1))	-2.066163 (0.14596) [-14.1556]
LOG(RHPRICE STL(-1))	-0.402874 (0.11865) [-3.39546]
C	5.429538

R-squared	0.609766	0.538809	0.667819
Adj. R-squared	0.502310	0.411814	0.576348
Sum sq. resids	0.000370	0.001179	0.003621
S.E. equation	0.002315	0.004134	0.007244
F-statistic	5.674582	4.242762	7.300939
Log likelihood	425.1323	373.5273	323.5951
Akaike AIC	-9.104097	-7.944434	-6.822362
Schwarz SC	-8.544853	-7.385190	-6.263118
Mean dependent	0.005788	0.003216	0.002195
S.D. dependent	0.003281	0.005390	0.011130

Dependent Variable: DLOG(RENT STLOUIS)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q4
Included observations: 95
Convergence achieved after 20 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.005921	0.000576	10.28078	0.0000
AR(1)	-0.286216	0.155208	-1.844081	0.0685
AR(2)	-0.397569	0.160388	-2.478796	0.0151
MA(1)	1.880496	0.062021	30.32048	0.0000
MA(2)	0.894060	0.063419	14.09765	0.0000
SIGMASQ	3.41E-06	4.44E-07	7.675288	0.0000

R-squared	0.658529	Mean dependent var	0.005768
Adjusted R-squared	0.639346	S.D. dependent var	0.003176
S.E. of regression	0.001907	Akaike info criterion	-9.539197
Sum squared resid	0.000324	Schwarz criterion	-9.377899
Log likelihood	459.1118	Hannan-Quinn criter.	-9.474020
F-statistic	34.32745	Durbin-Watson stat	1.584418
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT_STLOUIS_A	1.226429	0.3489
RENT_STLOUIS_V	0.714006	0.4602

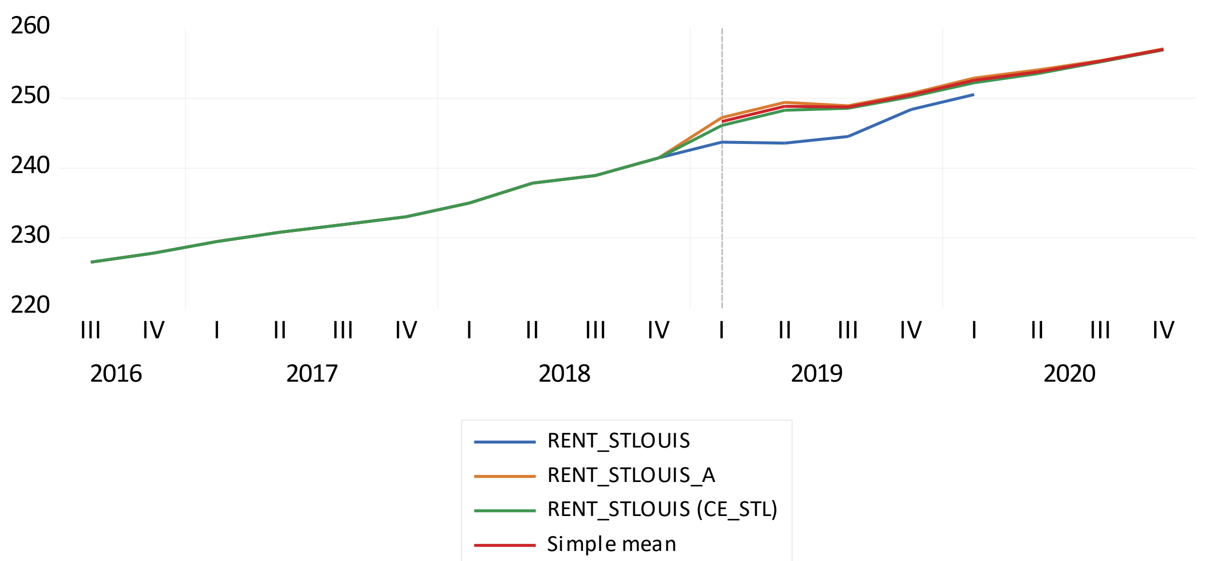
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	4.672922	0.0095	0.9953	0.0047
Sq Error	2.851362	0.0463	0.9768	0.0232

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT_STLOUIS_A	3.908381	3.672613	1.497300	1.484657	0.007880	1.772121
RENT_STLOUIS_V	3.177764	2.932226	1.195702	1.187328	0.006417	1.482179
Simple mean	3.539020	3.302420	1.346501	1.336125	0.007141	1.626149

Forecast Comparison Graph



Tampa

Vector Error Correction Estimates
Sample (adjusted): 1988Q2 2018Q4
Included observations: 123 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(RENT_TAM(-1))	1.000000
LOG(RINCOME_TAM(-1))	-28.28390 (6.30307) [-4.48732]
LOG(RHPRICE_TAM(-1))	2.000708 (1.89509) [1.05573]
C	143.8020

R-squared	0.750858	0.625771	0.614766
Adj. R-squared	0.721144	0.581138	0.568821
Sum sq. resids	0.000728	0.004101	0.023558
S.E. equation	0.002584	0.006134	0.014701
F-statistic	25.26932	14.02043	13.38039
Log likelihood	565.7822	459.4499	351.9388
Akaike AIC	-8.972068	-7.243088	-5.494940
Schwarz SC	-8.651982	-6.923002	-5.174854
Mean dependent	0.007708	0.001270	0.001755
S.D. dependent	0.004894	0.009478	0.022389

A

Dependent Variable: DLOG(RENT TAM)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1987Q2 2018Q4
Included observations: 127
Convergence achieved after 286 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007885	0.001483	5.318221	0.0000
AR(1)	-0.178892	0.083711	-2.137026	0.0347
AR(2)	0.109605	0.119897	0.914163	0.3625
AR(3)	0.184270	0.130730	1.409544	0.1613
AR(4)	0.244194	0.087661	2.785659	0.0062
MA(1)	1.032143	265.7213	0.003884	0.9969
MA(2)	1.032140	395.8760	0.002607	0.9979
MA(3)	0.999996	640.4021	0.001562	0.9988
SIGMASQ	4.95E-06	0.000206	0.024064	0.9808

R-squared	0.784962	Mean dependent var	0.007708
Adjusted R-squared	0.770384	S.D. dependent var	0.004816
S.E. of regression	0.002308	Akaike info criterion	-9.149656
Sum squared resid	0.000628	Schwarz criterion	-8.948099
Log likelihood	590.0031	Hannan-Quinn criter.	-9.067766
F-statistic	53.84268	Durbin-Watson stat	2.012722
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT_TAM_V	147.0837	0.0000
RENT_TAM_A	192.4001	0.0000

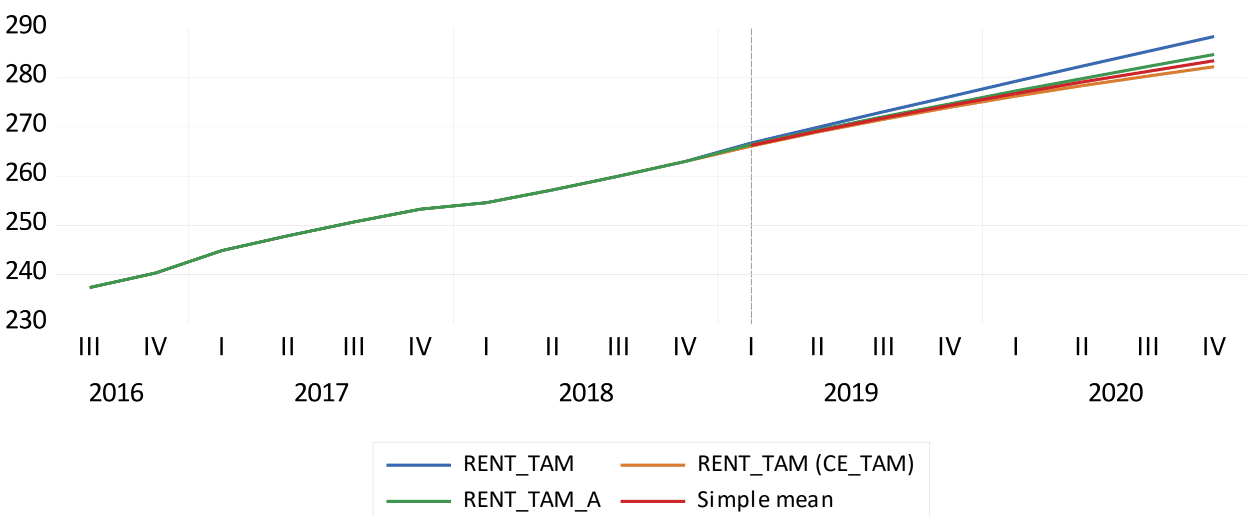
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	3.949182	0.0055	0.9972	0.0028
Sq Error	2.437615	0.0449	0.9775	0.0225

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT_TAM_V	3.466734	2.932658	1.040256	1.047749	0.006275	1.172032
RENT_TAM_A	2.133225	1.821201	0.646230	0.649063	0.003853	0.722530
Simple mean	2.799464	2.376930	0.843243	0.848124	0.005062	0.947117

Forecast Comparison Graph



Washington DC

Vector Error Correction Estimates
Sample (adjusted): 1999Q1 2018Q4
Included observations: 80 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(RENT DC(-1))	1.000000		
LOG(RINCOME DC(-1))	-1.660789 (0.19227) [-8.63762]		
LOG(RHPRICE DC(-1))	-0.168668 (0.07568) [-2.22858]		
C	3.776893		
R-squared	0.476026	0.263285	0.640342
Adj. R-squared	0.400088	0.156515	0.588217
Sum sq. resids	0.001083	0.005012	0.016567
S.E. equation	0.003961	0.008523	0.015495
F-statistic	6.268593	2.465903	12.28488
Log likelihood	334.8979	273.6033	225.7786
Akaike AIC	-8.097448	-6.565083	-5.369465
Schwarz SC	-7.769919	-6.237554	-5.041936
Mean dependent	0.008988	0.003920	0.006224
S.D. dependent	0.005114	0.009280	0.024147

Dependent Variable: DLOG(RENT DC,2)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1998Q3 2018Q4
Included observations: 82
Convergence achieved after 117 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000103	3.02E-05	-3.397305	0.0011
AR(1)	0.291053	0.157596	1.846831	0.0688
AR(2)	-0.954352	0.041391	-23.05719	0.0000
AR(3)	0.361861	0.154145	2.347533	0.0216
MA(1)	-0.843704	340.5570	-0.002477	0.9980
MA(2)	0.843699	421.2788	0.002003	0.9984
MA(3)	-0.999996	898.9993	-0.001112	0.9991
SIGMASQ	1.43E-05	0.002886	0.004956	0.9961

R-squared	0.444384	Mean dependent var	-0.000105
Adjusted R-squared	0.391826	S.D. dependent var	0.005105
S.E. of regression	0.003981	Akaike info criterion	-8.025030
Sum squared resid	0.001173	Schwarz criterion	-7.790228
Log likelihood	337.0262	Hannan-Quinn criter.	-7.930761
F-statistic	8.455078	Durbin-Watson stat	2.001843
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2019Q1 2020Q4
Included observations: 8
Evaluation sample: 2019Q1 2020Q4
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
RENT DC A	45.78543	0.0066
RENT DC V	17.48993	0.0249

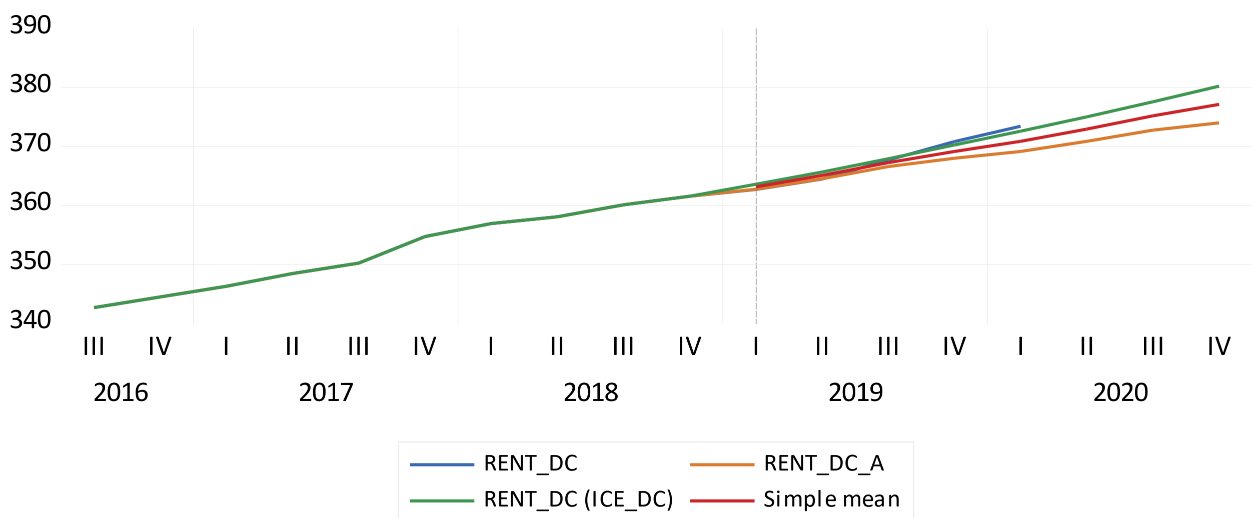
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	1.062348	0.3480	0.8260	0.1740
Sq Error	1.357908	0.2460	0.8770	0.1230

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
RENT DC A	2.343733	1.668093	0.448890	0.450879	0.003193	0.947617
RENT DC V	0.808615	0.736041	0.200472	0.200374	0.001099	0.288643
Simple mean	1.429282	1.162462	0.313909	0.314555	0.001945	0.571811

Forecast Comparison Graph



Atlanta

Vector Error Correction Estimates
Sample (adjusted): 1999Q1 2018Q1
Included observations: 77 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL ATL(-1))	1.000000		
LOG(NATGAS(-1))	0.382400		
	(0.04580)		
	[8.35007]		
LOG(ELEC(-1))	-1.456730		
	(0.09458)		
	[-15.4017]		
C	-9.134612		
R-squared	0.851910	0.334142	0.841251
Adj. R-squared	0.829472	0.233255	0.817199
Sum sq. resids	0.060909	1.958511	0.018223
S.E. equation	0.030379	0.172263	0.016617
F-statistic	37.96744	3.312029	34.97517
Log likelihood	165.7157	32.09913	212.1728
Akaike AIC	-4.018589	-0.548029	-5.225269
Schwarz SC	-3.683759	-0.213200	-4.890439
Mean dependent	0.009102	0.006146	0.006059
S.D. dependent	0.073565	0.196728	0.038864

Dependent Variable: DLOG(UTIL ATL)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1998Q2 2018Q2
Included observations: 81
Convergence achieved after 104 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009276	0.005998	1.546385	0.1264
AR(1)	-0.997035	0.015098	-66.03790	0.0000
AR(2)	-0.995646	0.017201	-57.88170	0.0000
AR(3)	-0.997341	0.005482	-181.9261	0.0000
MA(1)	1.379325	0.134787	10.23335	0.0000
MA(2)	1.274408	0.195834	6.507598	0.0000
MA(3)	1.243886	0.167223	7.438469	0.0000
MA(4)	0.404205	0.109307	3.697895	0.0004
SIGMASQ	0.000969	0.000132	7.342620	0.0000

R-squared	0.820545	Mean dependent var	0.009988
Adjusted R-squared	0.800605	S.D. dependent var	0.073930
S.E. of regression	0.033012	Akaike info criterion	-3.767790
Sum squared resid	0.078466	Schwarz criterion	-3.501740
Log likelihood	161.5955	Hannan-Quinn criter.	-3.661047
F-statistic	41.15183	Durbin-Watson stat	2.186887
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

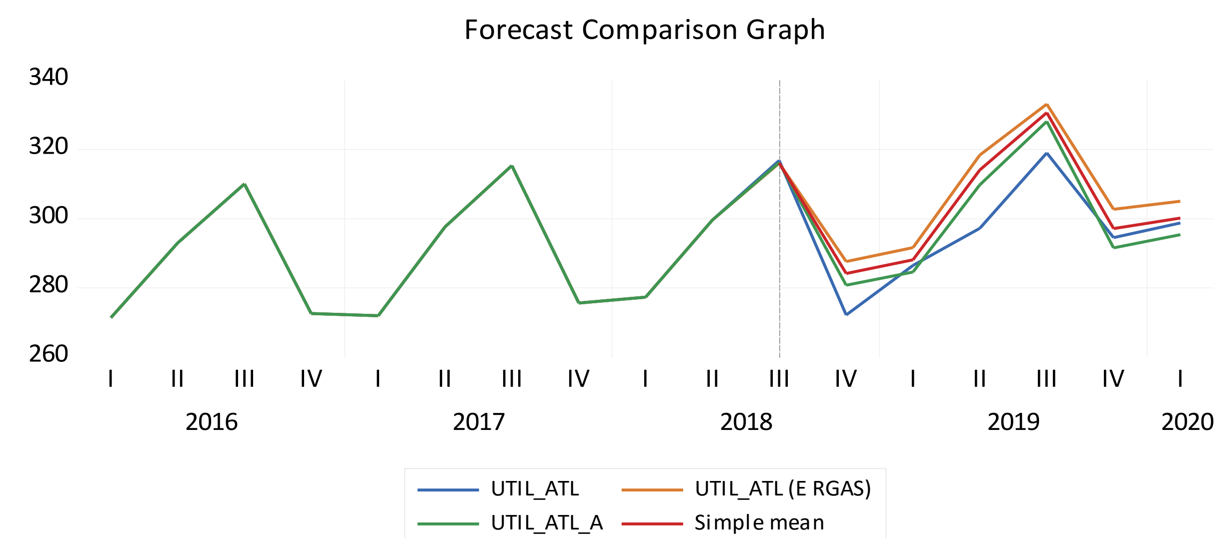
Forecast	F-stat	F-prob
UTIL ATL V	0.022193	0.8874
UTIL ATL A	0.794845	0.4135

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	4.393868	0.0046	0.9977	0.0023
Sq Error	2.494371	0.0469	0.9766	0.0234

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL ATL V	12.07970	10.17313	3.453975	3.371961	0.019921	0.570998
UTIL ATL A	6.963056	5.592218	1.891998	1.868683	0.011613	0.329948
Simple mean	9.077420	6.705208	2.272964	2.226657	0.015054	0.429949



Chicago

Vector Error Correction Estimates
Sample (adjusted): 1998Q3 2018Q1
Included observations: 79 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL CHI(-1))	1.000000		
LOG(GAS(-1))	0.045744		
	(0.04373)		
	[1.04599]		
LOG(E(-1))	-0.908960		
	(0.06235)		
	[-14.5792]		
C	-7.148573		
R-squared	0.684988	0.453516	0.915261
Adj. R-squared	0.603695	0.312488	0.893393
Sum sq. resids	0.094921	1.616194	0.010156
S.E. equation	0.039128	0.161455	0.012799
F-statistic	8.426137	3.215783	41.85373
Log likelihood	153.5080	41.53413	241.7882
Akaike AIC	-3.455898	-0.621117	-5.690841
Schwarz SC	-2.946017	-0.111236	-5.180960
Mean dependent	0.006158	0.003980	0.005513
S.D. dependent	0.062154	0.194720	0.039200

Dependent Variable: DLOG(UTIL CHI)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 183 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007002	0.000924	7.580150	0.0000
AR(1)	0.284026	0.079178	3.587166	0.0006
AR(2)	-0.015223	0.000269	-56.49452	0.0000
AR(3)	-0.627652	0.136931	-4.583695	0.0000
AR(4)	0.671596	0.271428	2.474308	0.0154
MA(1)	-0.272133	1.640889	-0.165845	0.8687
MA(2)	0.000291	0.228890	0.001273	0.9990
MA(3)	0.271657	0.993543	0.273423	0.7852
MA(4)	-0.999763	9.677144	-0.103312	0.9180
SIGMASQ	0.001818	0.002774	0.655346	0.5141

R-squared	0.464977	Mean dependent var	0.006243
Adjusted R-squared	0.406963	S.D. dependent var	0.058609
S.E. of regression	0.045134	Akaike info criterion	-3.139545
Sum squared resid	0.169078	Schwarz criterion	-2.867222
Log likelihood	155.9888	Hannan-Quinn criter.	-3.029589
F-statistic	8.014843	Durbin-Watson stat	1.737386
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

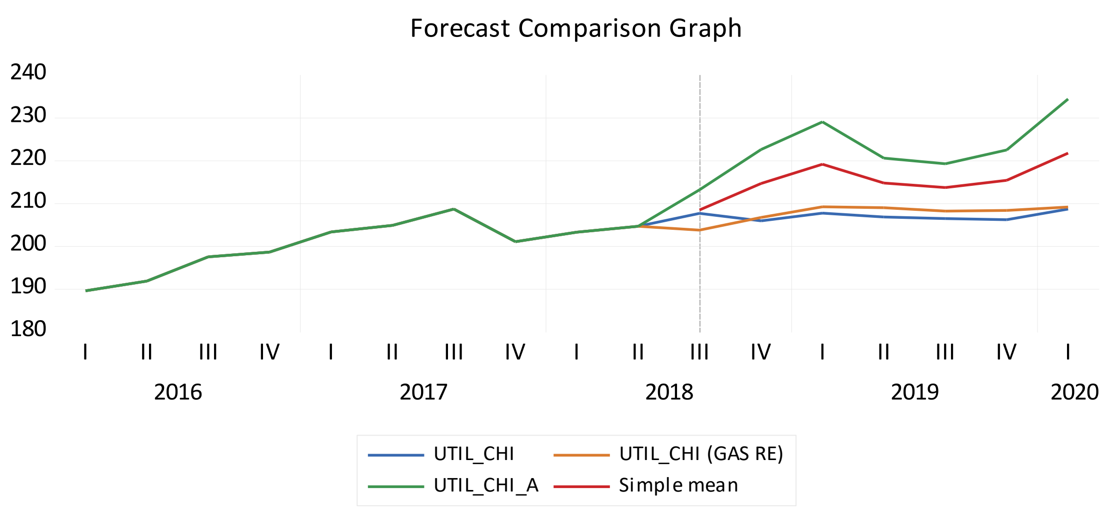
Forecast	F-stat	F-prob
UTIL_CHI_V	1.284317	0.3085
UTIL_CHI_A	7.431395	0.0415

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-5.059871	0.0023	0.0012	0.9988
Sq Error	-3.596849	0.0114	0.0057	0.9943

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_CHI_V	2.087913	1.814351	0.876181	0.876218	0.005032	1.062651
UTIL_CHI_A	17.07687	16.00680	7.724727	7.401186	0.039687	12.24761
Simple mean	9.095844	8.351153	4.031098	3.937241	0.021525	6.568658



Boston

Vector Error Correction Estimates
Sample (adjusted): 1998Q2 2018Q1
Included observations: 80 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL_BOS(-1))	1.000000		
LOG(GAS(-1))	-0.153925 (0.04845) [-3.17690]		
LOG(E(-1))	-1.656714 (0.07337) [-22.5801]		
C	-8.692369		
R-squared	0.702254	0.399058	0.908794
Adj. R-squared	0.643607	0.280691	0.890829
Sum sq. resids	0.094581	1.777566	0.010960
S.E. equation	0.037856	0.164112	0.012886
F-statistic	11.97428	3.371353	50.58716
Log likelihood	156.0981	38.75619	242.3073
Akaike AIC	-3.552452	-0.618905	-5.707684
Schwarz SC	-3.135597	-0.202050	-5.290829
Mean dependent	0.011240	0.004268	0.005734
S.D. dependent	0.063411	0.193501	0.039001

Dependent Variable: DLOG(UTIL BOS)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q4
Included observations: 95
Convergence achieved after 163 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009443	0.005955	1.585707	0.1164
AR(1)	0.005908	0.011137	0.530539	0.5971
AR(2)	-0.999939	0.000739	-1352.957	0.0000
MA(1)	0.402243	14.62346	0.027507	0.9781
MA(2)	1.002726	66.28978	0.015126	0.9880
MA(3)	0.395342	40.58853	0.009740	0.9923
SIGMASQ	0.001473	0.010269	0.143450	0.8863

R-squared	0.636528	Mean dependent var	0.009237
Adjusted R-squared	0.611746	S.D. dependent var	0.063999
S.E. of regression	0.039878	Akaike info criterion	-3.445312
Sum squared resid	0.139941	Schwarz criterion	-3.257131
Log likelihood	170.6523	Hannan-Quinn criter.	-3.369273
F-statistic	25.68493	Durbin-Watson stat	1.933443
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

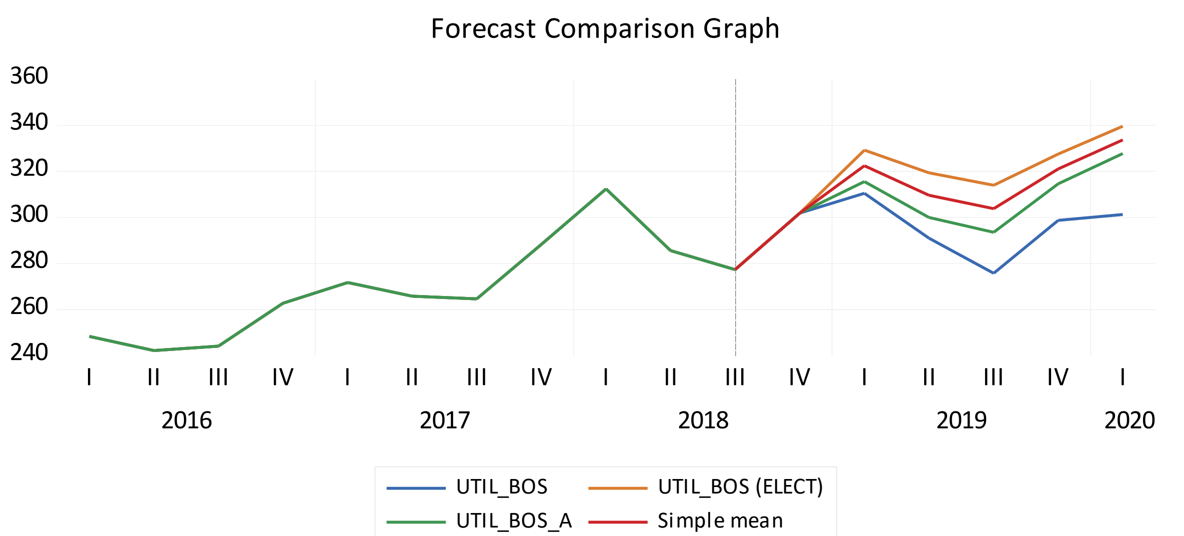
Forecast	F-stat	F-prob
UTIL BOS V	1.952593	0.2212
UTIL BOS A	5.784938	0.0612

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	3.567642	0.0118	0.9941	0.0059
Sq Error	3.159600	0.0196	0.9902	0.0098

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL BOS V	26.47990	21.76591	7.426230	7.036262	0.043404	1.595107
UTIL BOS A	14.00512	10.59277	3.608919	3.499219	0.023392	0.846727
Simple mean	20.06844	16.17934	5.517574	5.292005	0.033205	1.211037



Dallas

Vector Error Correction Estimates
Sample (adjusted): 1998Q2 2018Q1
Included observations: 80 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(UTIL_DAL(-1))	1.000000
LOG(GAS(-1))	-0.257029
	(0.03471)
	[-7.40557]
LOG(E(-1))	-1.128367
	(0.05785)
	[-19.5056]
C	-7.368546

R-squared	0.722030	0.409609	0.896581
Adj. R-squared	0.667278	0.293320	0.876210
Sum sq. resids	0.059407	1.746356	0.012427
S.E. equation	0.030002	0.162665	0.013722
F-statistic	13.18735	3.522336	44.01373
Log likelihood	174.6994	39.46473	237.2807
Akaike AIC	-4.017485	-0.636618	-5.582017
Schwarz SC	-3.600630	-0.219764	-5.165162
Mean dependent	0.007492	0.004268	0.005734
S.D. dependent	0.052013	0.193501	0.039001

Dependent Variable: D(UTIL DAL)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence not achieved after 500 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.118524	0.979098	1.142403	0.2565
AR(1)	-0.944092	0.061743	-15.29071	0.0000
AR(2)	-0.998609	0.015429	-64.72280	0.0000
AR(3)	-0.945106	0.061128	-15.46098	0.0000
MA(1)	1.168960	14.45059	0.080894	0.9357
MA(2)	1.297003	98.20726	0.013207	0.9895
MA(3)	1.181647	123.2902	0.009584	0.9924
MA(4)	0.319158	37.36947	0.008541	0.9932
SIGMASQ	46.52758	3052.042	0.015245	0.9879

R-squared	0.440807	Mean dependent var	1.155737
Adjusted R-squared	0.387550	S.D. dependent var	9.171109
S.E. of regression	7.177233	Akaike info criterion	6.951051
Sum squared resid	4327.065	Schwarz criterion	7.196142
Log likelihood	-314.2239	Hannan-Quinn criter.	7.050012
F-statistic	8.277053	Durbin-Watson stat	2.034441
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

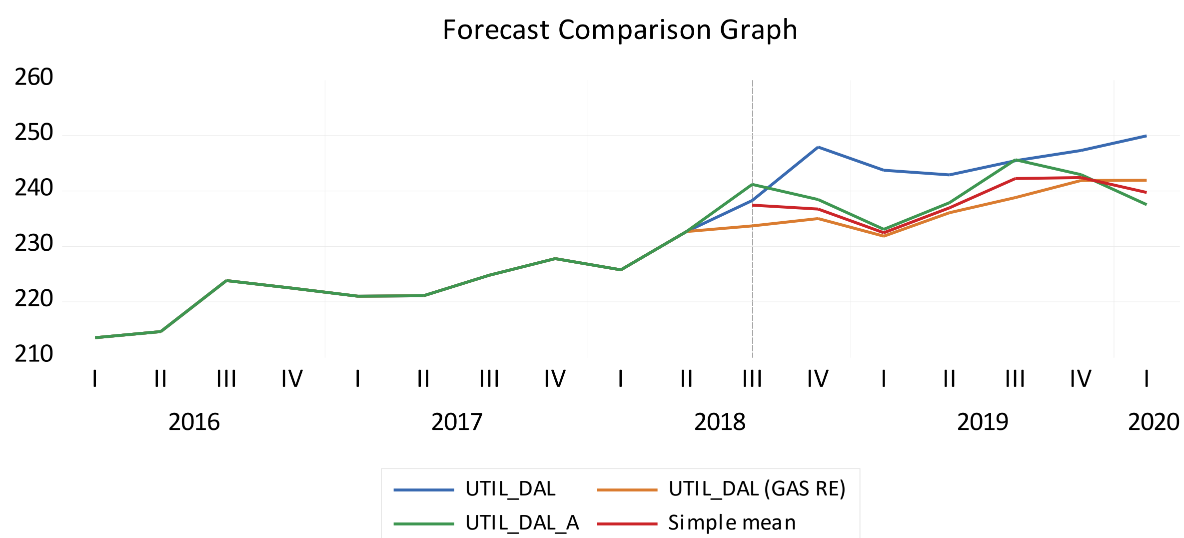
Forecast	F-stat	F-prob
UTIL DAL V	3.683734	0.1130
UTIL DAL A	0.039884	0.8496

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	1.302498	0.2405	0.8797	0.1203
Sq Error	0.752776	0.4801	0.7600	0.2400

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL DAL V	8.573861	8.051352	3.278759	3.340827	0.017781	1.930412
UTIL DAL A	7.671192	6.449111	2.619438	2.666535	0.015827	1.733639
Simple mean	7.821000	6.803948	2.762135	2.813457	0.016178	1.790958



Denver

Vector Error Correction Estimates
Sample (adjusted): 1997Q4 2018Q1
Included observations: 82 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL DEN(-1))	1.000000		
LOG(GAS(-1))	0.188158		
	(0.06930)		
	[2.71528]		
LOG(E(-1))	-0.940580		
	(0.15684)		
	[-5.99692]		
C	-7.523256		
R-squared	0.614591	0.349228	0.472664
Adj. R-squared	0.578133	0.287668	0.422780
Sum sq. resids	0.039357	1.974251	0.069680
S.E. equation	0.023062	0.163337	0.030686
F-statistic	16.85768	5.673014	9.475411
Log likelihood	196.9608	36.43477	173.5401
Akaike AIC	-4.608801	-0.693531	-4.037564
Schwarz SC	-4.373999	-0.458729	-3.802762
Mean dependent	0.007972	0.002434	0.003824
S.D. dependent	0.035506	0.193528	0.040389

Dependent Variable: D(UTIL DEN)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 52 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.309189	0.149528	8.755466	0.0000
AR(1)	0.656551	0.075081	8.744587	0.0000
MA(1)	0.945876	19.32708	0.048940	0.9611
MA(2)	-0.999988	23.84679	-0.041934	0.9666
MA(3)	-0.945864	11.66451	-0.081089	0.9356
SIGMASQ	6.564962	70.49408	0.093128	0.9260

R-squared	0.819755	Mean dependent var	1.289280
Adjusted R-squared	0.809396	S.D. dependent var	6.067818
S.E. of regression	2.649098	Akaike info criterion	5.004119
Sum squared resid	610.5415	Schwarz criterion	5.167513
Log likelihood	-226.6915	Hannan-Quinn criter.	5.070093
F-statistic	79.13547	Durbin-Watson stat	1.825054
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

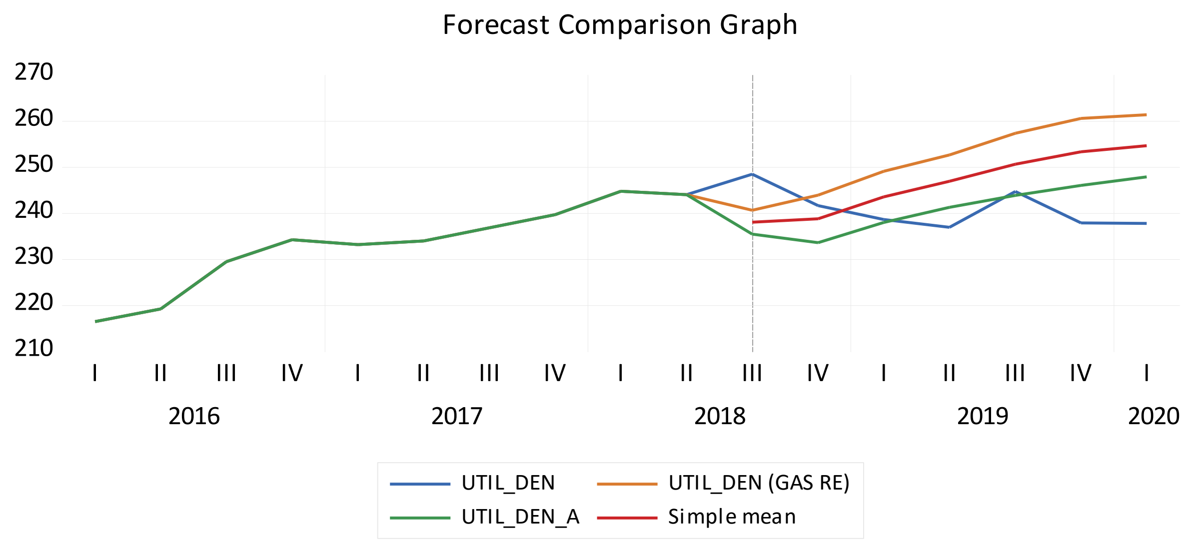
Forecast	F-stat	F-prob
UTIL_DEN_V	18.91634	0.0074
UTIL_DEN_A	30.47822	0.0027

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	2.166986	0.0734	0.9633	0.0367
Sq Error	2.100051	0.0805	0.9598	0.0402

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_DEN_V	15.38560	13.61650	5.682550	5.497318	0.031190	3.135693
UTIL_DEN_A	7.770974	6.447592	2.669221	2.674178	0.016127	1.238224
Simple mean	10.68477	9.489271	3.951384	3.881742	0.021914	2.061326



Detroit

Vector Error Correction Estimates
Sample (adjusted): 1997Q3 2020Q1
Included observations: 91 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL DET(-1))	1.000000		
LOG(RGAS(-1))	-15.36472		
	(21.9507)		
	[-0.69997]		
LOG(RE(-1))	-747.0334		
	(215.732)		
	[-3.46278]		
C	5384.876		
R-squared	0.114648	0.127790	0.283284
Adj. R-squared	0.073469	0.087222	0.249948
Sum sq. resids	0.061197	2.522122	0.038216
S.E. equation	0.026676	0.171251	0.021080
F-statistic	2.784130	3.150026	8.497929
Log likelihood	203.2322	34.02862	224.6552
Akaike AIC	-4.356752	-0.637992	-4.827588
Schwarz SC	-4.218793	-0.500032	-4.689628
Mean dependent	0.007864	-0.006143	-0.000852
S.D. dependent	0.027713	0.179247	0.024340

Dependent Variable: D(UTIL DET)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 23 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.453160	0.603561	2.407645	0.0182
AR(1)	0.019751	0.091530	0.215787	0.8297
AR(2)	-0.910758	0.073464	-12.39740	0.0000
MA(1)	0.093133	0.117061	0.795587	0.4284
MA(2)	0.829508	0.117392	7.066165	0.0000
SIGMASQ	26.79411	3.090216	8.670626	0.0000

R-squared	0.118090	Mean dependent var	1.442652
Adjusted R-squared	0.067406	S.D. dependent var	5.541855
S.E. of regression	5.351820	Akaike info criterion	6.261405
Sum squared resid	2491.852	Schwarz criterion	6.424799
Log likelihood	-285.1553	Hannan-Quinn criter.	6.327379
F-statistic	2.329908	Durbin-Watson stat	2.152597
Prob(F-statistic)	0.049087		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

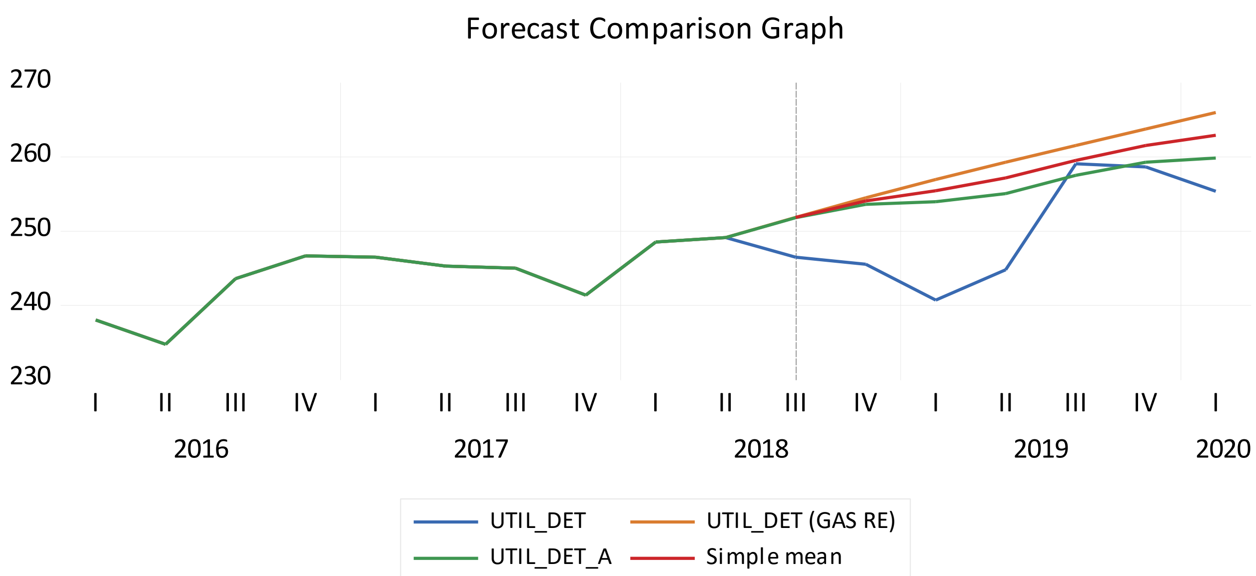
Forecast	F-stat	F-prob
UTIL DET V	0.266872	0.6275
UTIL DET A	1.351548	0.2975

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	3.266878	0.0171	0.9914	0.0086
Sq Error	2.722249	0.0345	0.9827	0.0173

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL DET V	10.20383	9.038486	3.655071	3.570990	0.020032	1.641452
UTIL DET A	7.537979	6.231502	2.537275	2.491006	0.014895	1.200225
Simple mean	8.766258	7.412332	3.010235	2.947509	0.017266	1.404944



Honolulu

Vector Error Correction Estimates
Sample (adjusted): 1997Q4 2018Q2
Included observations: 83 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(UTIL HON(-1))	1.000000
LOG(RGAS(-1))	-1.279043 (0.33901) [-3.77293]
LOG(RE(-1))	-9.836193 (3.34852) [-2.93748]
C	-72.39858

R-squared	0.667496	0.243299	0.326307
Adj. R-squared	0.636462	0.172674	0.263429
Sum sq. resids	0.056883	2.016876	0.035239
S.E. equation	0.027540	0.163987	0.021676
F-statistic	21.50869	3.444927	5.189524
Log likelihood	184.5802	36.49566	204.4523
Akaike AIC	-4.254946	-0.686642	-4.733790
Schwarz SC	-4.021804	-0.453501	-4.500648
Mean dependent	0.011307	-0.004095	-0.001200
S.D. dependent	0.045676	0.180290	0.025257

Dependent Variable: DLOG(UTIL HON)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.010216	0.006678	1.529915	0.1297
MA(1)	1.754519	0.165845	10.57929	0.0000
MA(2)	0.343141	0.239884	1.430444	0.1562
MA(3)	-0.724849	0.206424	-3.511460	0.0007
MA(4)	-0.287723	0.163625	-1.758426	0.0822
SIGMASQ	0.000397	4.51E-05	8.788294	0.0000

R-squared	0.785081	Mean dependent var	0.010994
Adjusted R-squared	0.772730	S.D. dependent var	0.043198
S.E. of regression	0.020594	Akaike info criterion	-4.775625
Sum squared resid	0.036897	Schwarz criterion	-4.612232
Log likelihood	228.0666	Hannan-Quinn criter.	-4.709652
F-statistic	63.56088	Durbin-Watson stat	1.891398
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

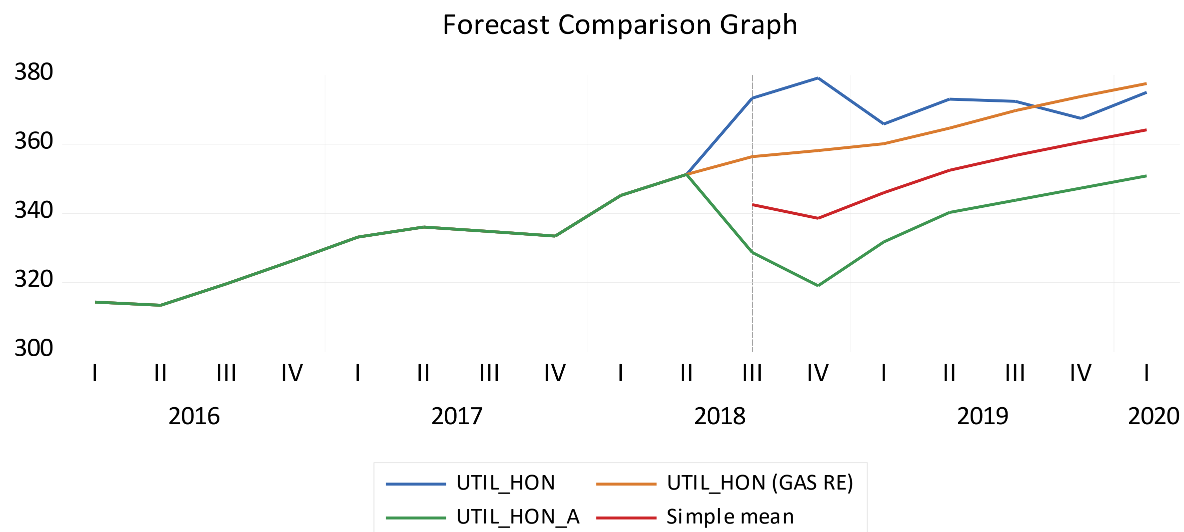
Forecast	F-stat	F-prob
UTIL_HON_V	28.41013	0.0031
UTIL_HON_A	10.39915	0.0233

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-8.928509	0.0001	0.0001	0.9999
Sq Error	-3.485731	0.0131	0.0065	0.9935

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_HON_V	11.27237	9.102948	2.434228	2.475346	0.015270	1.320707
UTIL_HON_A	37.16865	34.96684	9.368782	9.892696	0.052358	4.720249
Simple mean	23.39795	20.76654	5.558280	5.761357	0.032315	2.891542



Houston

Vector Error Correction Estimates
Sample (adjusted): 1998Q1 2018Q2
Included observations: 82 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL_HOU(-1))	1.000000		
LOG(RGAS(-1))	0.183493		
	(0.51489)		
	[0.35637]		
LOG(RE(-1))	-15.70069		
	(4.71227)		
	[-3.33188]		
C	110.1646		
R-squared	0.480110	0.344206	0.316082
Adj. R-squared	0.406886	0.251841	0.219756
Sum sq. resids	0.137779	1.739795	0.035602
S.E. equation	0.044052	0.156538	0.022393
F-statistic	6.556734	3.726572	3.281361
Log likelihood	145.5888	41.61808	201.0725
Akaike AIC	-3.282655	-0.746782	-4.635914
Schwarz SC	-2.959802	-0.423930	-4.313061
Mean dependent	0.005978	-0.005445	-0.001007
S.D. dependent	0.057200	0.180977	0.025351

Dependent Variable: D(UTIL HOU)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 32 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.806407	0.946844	0.851679	0.3968
AR(1)	-0.525209	0.234584	-2.238892	0.0278
AR(2)	-1.025619	0.032636	-31.42560	0.0000
AR(3)	-0.425994	0.229154	-1.858983	0.0665
MA(1)	0.879950	0.190080	4.629367	0.0000
MA(2)	1.036424	0.114240	9.072318	0.0000
MA(3)	0.670911	0.179626	3.735037	0.0003
SIGMASQ	45.75013	6.150821	7.438052	0.0000

R-squared	0.320781	Mean dependent var	0.858108
Adjusted R-squared	0.264845	S.D. dependent var	8.251612
S.E. of regression	7.075028	Akaike info criterion	6.858308
Sum squared resid	4254.762	Schwarz criterion	7.076166
Log likelihood	-310.9113	Hannan-Quinn criter.	6.946273
F-statistic	5.734819	Durbin-Watson stat	2.031997
Prob(F-statistic)	0.000019		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
UTIL_HOU_V	0.353473	0.5780
UTIL_HOU_A	1.212471	0.3210

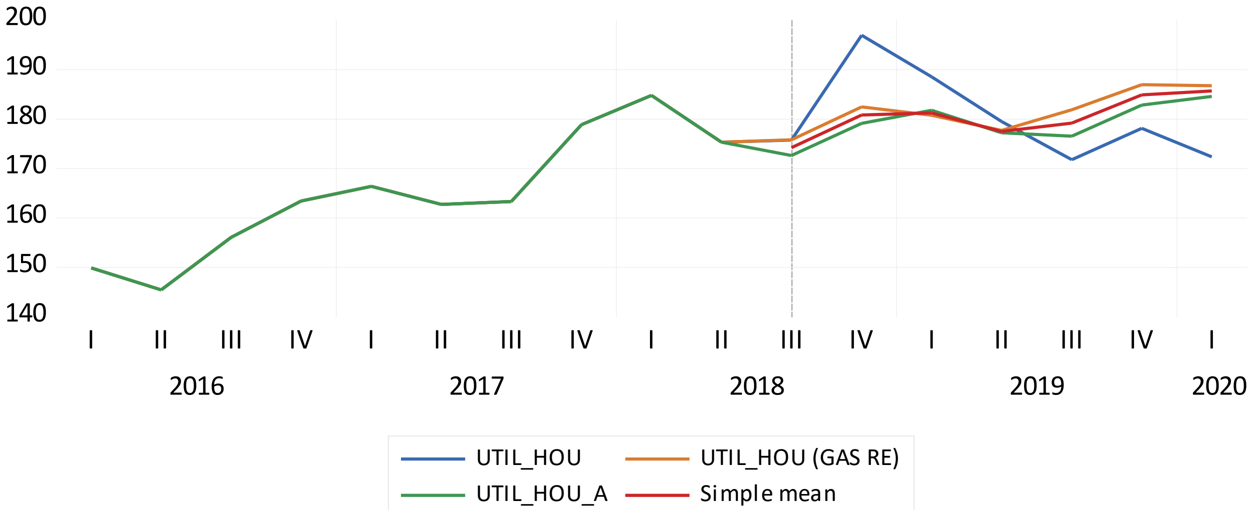
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	0.638984	0.5464	0.7268	0.2732
Sq Error	0.523167	0.6196	0.6902	0.3098

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_HOU_V	9.713977	8.197337	4.523841	4.488189	0.026802	0.951414
UTIL_HOU_A	9.049008	7.383059	4.026729	4.056146	0.025143	0.880219
Simple mean	9.247176	7.786710	4.273301	4.271715	0.025604	0.904457

Forecast Comparison Graph



Miami

Vector Error Correction Estimates
Sample (adjusted): 1997Q4 2018Q2
Included observations: 83 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL MIA(-1))	1.000000		
LOG(RGAS(-1))	31.31014		
	(35.6213)		
	[0.87897]		
LOG(RE(-1))	-982.1091		
	(339.748)		
	[-2.89070]		
C	-7051.688		
R-squared	0.308747	0.222348	0.322738
Adj. R-squared	0.244230	0.149767	0.259527
Sum sq. resids	0.039570	2.072719	0.035426
S.E. equation	0.022969	0.166242	0.021733
F-statistic	4.785508	3.063454	5.105723
Log likelihood	199.6423	35.36225	204.2330
Akaike AIC	-4.617888	-0.659331	-4.728507
Schwarz SC	-4.384747	-0.426190	-4.495365
Mean dependent	0.004784	-0.004095	-0.001200
S.D. dependent	0.026421	0.180290	0.025257

Dependent Variable: D(UTIL MIA)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 89 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.680742	0.458836	1.483630	0.1416
AR(1)	1.528862	0.064763	23.60708	0.0000
AR(2)	-0.925098	0.066955	-13.81668	0.0000
MA(1)	-1.495044	56.88823	-0.026280	0.9791
MA(2)	0.756257	77.36991	0.009775	0.9922
MA(3)	0.387380	16.09735	0.024065	0.9809
MA(4)	-0.280570	23.16708	-0.012111	0.9904
SIGMASQ	11.58448	832.6966	0.013912	0.9889

R-squared	0.217826	Mean dependent var	0.709314
Adjusted R-squared	0.153411	S.D. dependent var	3.869315
S.E. of regression	3.560166	Akaike info criterion	5.514507
Sum squared resid	1077.356	Schwarz criterion	5.732365
Log likelihood	-248.4246	Hannan-Quinn criter.	5.602472
F-statistic	3.381634	Durbin-Watson stat	1.973588
Prob(F-statistic)	0.003122		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

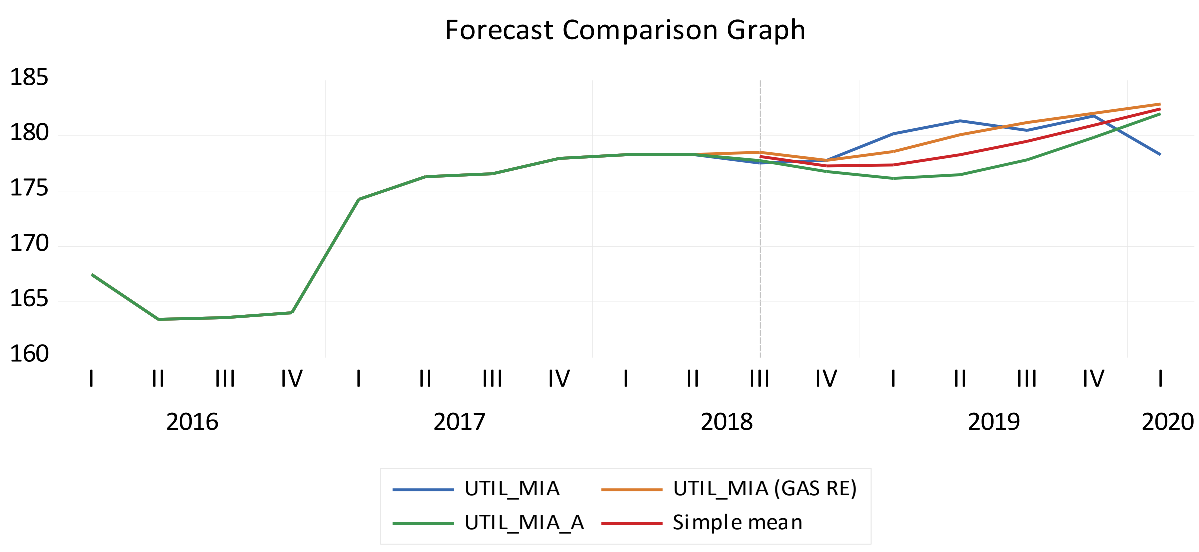
Forecast	F-stat	F-prob
UTIL_MIA_V	18.43529	0.0078
UTIL_MIA_A	0.778170	0.4181

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-2.074409	0.0834	0.0417	0.9583
Sq Error	-1.501271	0.1840	0.0920	0.9080

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_MIA_V	1.953885	1.339365	0.747508	0.743395	0.005430	1.075093
UTIL_MIA_A	3.063848	2.636108	1.463298	1.471709	0.008564	1.728723
Simple mean	2.293943	1.851990	1.030306	1.030642	0.006394	1.285437



Philadelphia

Vector Error Correction Estimates
Sample (adjusted): 1998Q2 2018Q2
Included observations: 81 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(UTIL_PHIL(-1))	1.000000
LOG(RGAS(-1))	0.047029
	(0.38470)
	[0.12225]
LOG(RE(-1))	-10.58755
	(2.94434)
	[-3.59589]
C	72.21650

R-squared	0.666998	0.344205	0.366088
Adj. R-squared	0.602386	0.216961	0.243091
Sum sq. resids	0.024246	1.705942	0.032111
S.E. equation	0.019023	0.159568	0.021892
F-statistic	10.32309	2.705079	2.976382
Log likelihood	213.6808	41.40942	202.3029
Akaike AIC	-4.930389	-0.676776	-4.649453
Schwarz SC	-4.516534	-0.262920	-4.235598
Mean dependent	0.005764	-0.002657	-0.000548
S.D. dependent	0.030168	0.180324	0.025163

Dependent Variable: DLOG(UTIL PHIL)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 52 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.005638	0.003430	1.643657	0.1040
AR(1)	-0.694609	0.179743	-3.864460	0.0002
AR(2)	-0.680723	0.177122	-3.843242	0.0002
AR(3)	-0.657469	0.167227	-3.931583	0.0002
AR(4)	0.296324	0.159261	1.860619	0.0663
MA(1)	0.966420	0.128165	7.540421	0.0000
MA(2)	0.851819	0.151332	5.628814	0.0000
MA(3)	0.701746	0.103806	6.760175	0.0000
SIGMASQ	0.000435	6.17E-05	7.055843	0.0000

R-squared	0.497324	Mean dependent var	0.005822
Adjusted R-squared	0.449450	S.D. dependent var	0.029578
S.E. of regression	0.021947	Akaike info criterion	-4.673523
Sum squared resid	0.040460	Schwarz criterion	-4.428432
Log likelihood	226.3188	Hannan-Quinn criter.	-4.574562
F-statistic	10.38819	Durbin-Watson stat	1.990021
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

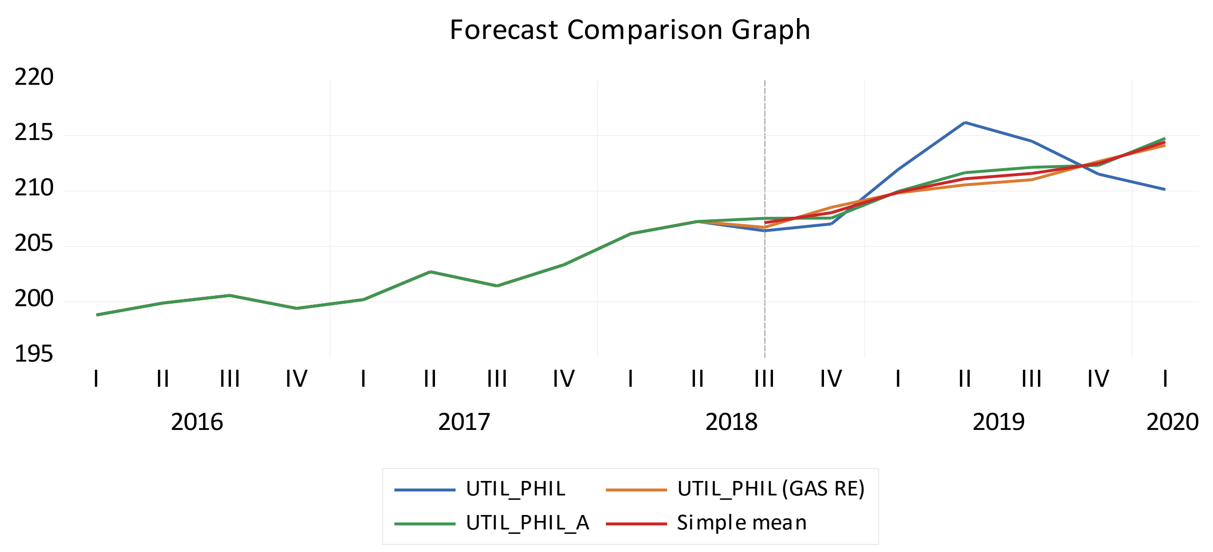
Forecast	F-stat	F-prob
UTIL_PHIL_V	0.030054	0.8692
UTIL_PHIL_A	0.478993	0.5197

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	1.046795	0.3355	0.8322	0.1678
Sq Error	1.008704	0.3521	0.8240	0.1760

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_PHIL_V	3.116373	2.598663	1.221292	1.225680	0.007391	1.089042
UTIL_PHIL_A	2.765644	2.280009	1.073557	1.074436	0.006554	0.957001
Simple mean	2.918201	2.439336	1.147425	1.150044	0.006918	1.016681



New York

Vector Error Correction Estimates
Sample (adjusted): 1998Q2 2018Q2
Included observations: 81 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL_NY(-1))	1.000000		
LOG(RGAS(-1))	-1.009016		
	(0.26531)		
	[-3.80312]		
LOG(RE(-1))	-3.866921		
	(2.08379)		
	[-1.85572]		
C	26.84237		
R-squared	0.531075	0.339352	0.329601
Adj. R-squared	0.440090	0.211166	0.199524
Sum sq. resids	0.057580	1.718566	0.033959
S.E. equation	0.029316	0.160157	0.022513
F-statistic	5.836927	2.647349	2.533884
Log likelihood	178.6514	41.11081	200.0363
Akaike AIC	-4.065467	-0.669403	-4.593490
Schwarz SC	-3.651611	-0.255547	-4.179634
Mean dependent	0.006615	-0.002657	-0.000548
S.D. dependent	0.039178	0.180324	0.025163

Dependent Variable: DLOG(UTIL NY)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 92 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006603	0.004710	1.402042	0.1646
AR(1)	0.180680	0.165878	1.089235	0.2792
AR(2)	0.069250	0.063842	1.084702	0.2812
AR(3)	-0.872019	1.308907	-0.666219	0.5071
AR(4)	0.239411	0.491548	0.487055	0.6275
MA(1)	-0.087159	0.051941	-1.678052	0.0971
MA(2)	-0.089148	0.051959	-1.715740	0.0899
MA(3)	0.997928	0.001714	582.2854	0.0000
SIGMASQ	0.000904	0.000144	6.270713	0.0000

R-squared	0.332176	Mean dependent var	0.006231
Adjusted R-squared	0.268573	S.D. dependent var	0.037000
S.E. of regression	0.031644	Akaike info criterion	-3.896163
Sum squared resid	0.084110	Schwarz criterion	-3.651073
Log likelihood	190.1716	Hannan-Quinn criter.	-3.797202
F-statistic	5.222694	Durbin-Watson stat	1.925221
Prob(F-statistic)	0.000026		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

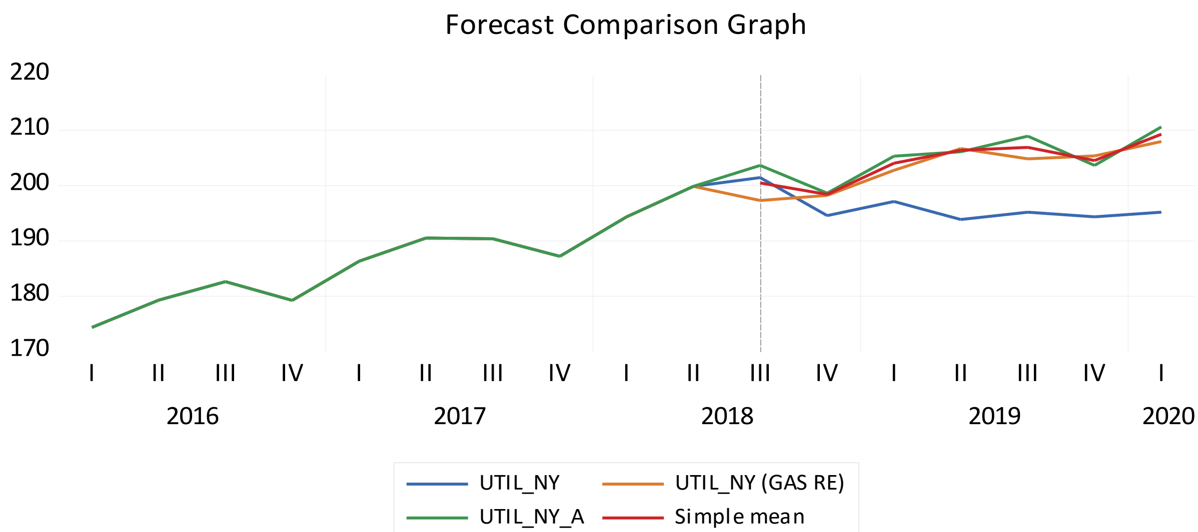
Forecast	F-stat	F-prob
UTIL_NY_V	2.136196	0.2037
UTIL_NY_A	44.01341	0.0012

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-0.875706	0.4149	0.2074	0.7926
Sq Error	-1.130583	0.3014	0.1507	0.8493

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_NY_V	9.288154	8.526364	4.365017	4.260731	0.023258	3.004394
UTIL_NY_A	10.35783	9.304840	4.765654	4.629082	0.025810	3.394171
Simple mean	9.702106	8.600348	4.408854	4.288930	0.024235	3.184732



San Francisco

Vector Error Correction Estimates
Sample (adjusted): 1997Q4 2018Q2
Included observations: 83 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL_SF(-1))	1.000000		
LOG(RGAS(-1))	0.224027		
	(1.00688)		
	[0.22250]		
LOG(RE(-1))	-29.14489		
	(9.89743)		
	[-2.94469]		
C	-217.2111		
R-squared	0.241107	0.206813	0.397744
Adj. R-squared	0.170277	0.132783	0.341533
Sum sq. resids	0.077634	2.114124	0.031502
S.E. equation	0.032173	0.167894	0.020495
F-statistic	3.404025	2.793616	7.075956
Log likelihood	171.6738	34.54140	209.1041
Akaike AIC	-3.943948	-0.639552	-4.845881
Schwarz SC	-3.710807	-0.406411	-4.612740
Mean dependent	0.011655	-0.004095	-0.001200
S.D. dependent	0.035321	0.180290	0.025257

Dependent Variable: DLOG(UTIL SF)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q3
Included observations: 94
Convergence achieved after 280 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.011725	0.000856	13.70373	0.0000
AR(1)	0.588449	0.095444	6.165387	0.0000
AR(2)	-0.746000	0.059533	-12.53091	0.0000
AR(3)	0.799701	0.103270	7.743769	0.0000
MA(1)	-0.562579	137.3761	-0.004095	0.9967
MA(2)	0.562574	157.8631	0.003564	0.9972
MA(3)	-0.999991	518.3279	-0.001929	0.9985
SIGMASQ	0.000821	0.093027	0.008822	0.9930

R-squared	0.322556	Mean dependent var	0.010815
Adjusted R-squared	0.267415	S.D. dependent var	0.034992
S.E. of regression	0.029950	Akaike info criterion	-4.010398
Sum squared resid	0.077144	Schwarz criterion	-3.793947
Log likelihood	196.4887	Hannan-Quinn criter.	-3.922968
F-statistic	5.849673	Durbin-Watson stat	2.063916
Prob(F-statistic)	0.000014		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Forecast	F-stat	F-prob
UTIL SF V	0.618249	0.4673
UTIL SF A	4.103345	0.0987

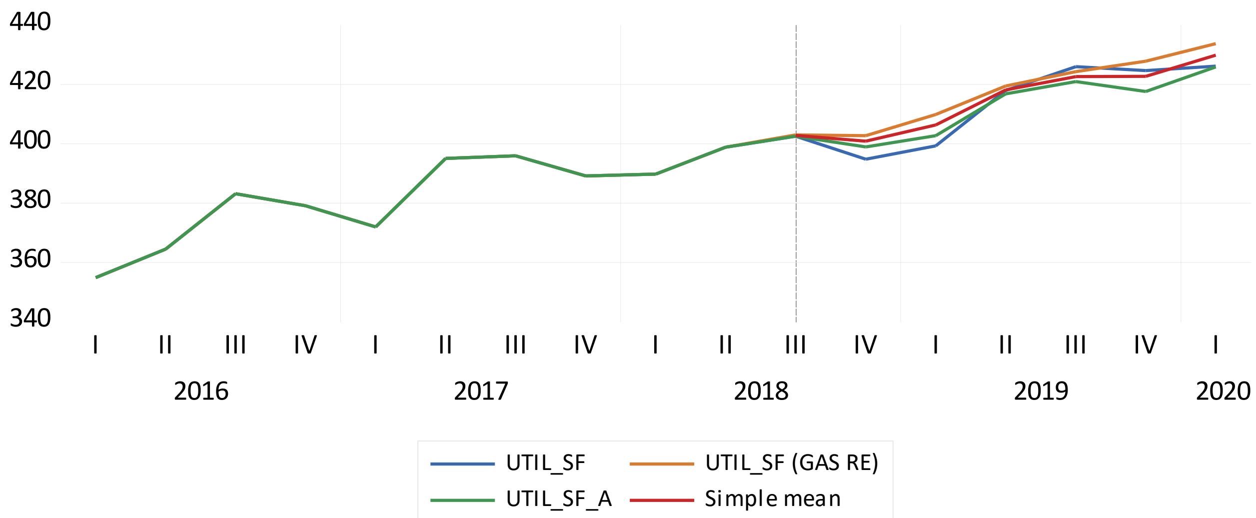
Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	0.982881	0.3636	0.8182	0.1818
Sq Error	1.109168	0.3098	0.8451	0.1549

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL SF V	5.953861	4.691385	1.147910	1.137444	0.007167	0.702203
UTIL SF A	3.849321	2.991940	0.722332	0.724040	0.004662	0.441980
Simple mean	4.020194	3.174803	0.777495	0.773714	0.004854	0.475566

Forecast Comparison Graph



San Diego

Vector Error Correction Estimates
Sample (adjusted): 1998Q2 2018Q2
Included observations: 81 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL_SD(-1))	1.000000		
LOG(RGAS(-1))	1.009910		
	(0.58452)		
	[1.72776]		
LOG(RE(-1))	-19.60210		
	(6.12496)		
	[-3.20037]		
C	141.4624		
R-squared	0.687830	0.358476	0.331309
Adj. R-squared	0.627259	0.234001	0.201563
Sum sq. resids	0.016516	1.668817	0.033873
S.E. equation	0.015701	0.157822	0.022485
F-statistic	11.35588	2.879911	2.553516
Log likelihood	229.2299	42.30052	200.1396
Akaike AIC	-5.314319	-0.698778	-4.596040
Schwarz SC	-4.900464	-0.284923	-4.182185
Mean dependent	0.012514	-0.002657	-0.000548
S.D. dependent	0.025716	0.180324	0.025163

Dependent Variable: D(UTIL SD)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1995Q2 2018Q2
Included observations: 93
Convergence achieved after 8 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.409791	1.081131	2.228954	0.0283
MA(1)	1.762817	0.098875	17.82877	0.0000
MA(2)	0.775180	0.104372	7.427102	0.0000
SIGMASQ	4.951118	0.520830	9.506207	0.0000

R-squared	0.740534	Mean dependent var	2.237140
Adjusted R-squared	0.731788	S.D. dependent var	4.391964
S.E. of regression	2.274564	Akaike info criterion	4.589258
Sum squared resid	460.4540	Schwarz criterion	4.698187
Log likelihood	-209.4005	Hannan-Quinn criter.	4.633240
F-statistic	84.67063	Durbin-Watson stat	1.940482
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

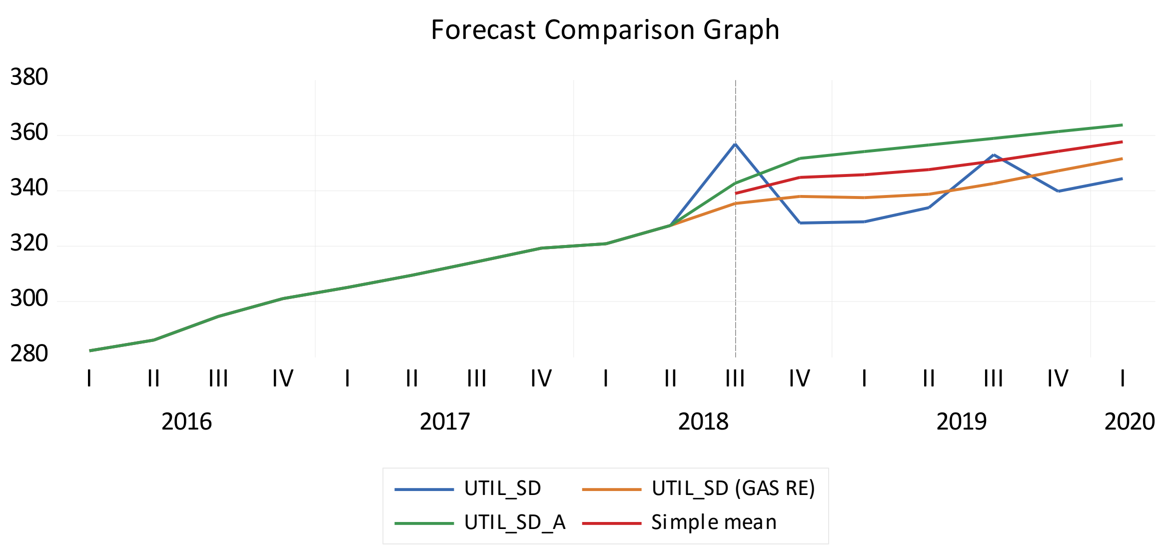
Forecast	F-stat	F-prob
UTIL_SD_V	2.667567	0.1633
UTIL_SD_A	0.536441	0.4968

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-2.282064	0.0626	0.0313	0.9687
Sq Error	-2.293348	0.0617	0.0308	0.9692

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_SD_V	11.14760	9.959233	2.896812	2.910988	0.016332	0.552315
UTIL_SD_A	19.92825	18.91822	5.605189	5.457071	0.028607	1.391166
Simple mean	14.44626	13.59587	4.012291	3.959588	0.020949	0.923746



Phoenix

Vector Error Correction Estimates
Sample (adjusted): 2003Q2 2018Q2
Included observations: 61 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL_PHO(-1))	1.000000		
LOG(RGAS(-1))	0.518929		
	(0.07969)		
	[6.51220]		
LOG(RE(-1))	-0.154497		
	(0.69432)		
	[-0.22252]		
C	-4.182353		
R-squared	0.809651	0.339693	0.375769
Adj. R-squared	0.757002	0.157055	0.203109
Sum sq. resids	0.012892	1.069967	0.027319
S.E. equation	0.016562	0.150882	0.024109
F-statistic	15.37810	1.859925	2.176352
Log likelihood	171.5367	36.76375	148.6318
Akaike AIC	-5.165137	-0.746352	-4.414158
Schwarz SC	-4.680674	-0.261890	-3.929695
Mean dependent	0.007091	-0.019400	0.000236
S.D. dependent	0.033598	0.164337	0.027007

Dependent Variable: DLOG(UTIL PHO)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 2002Q2 2018Q2
Included observations: 65
Convergence achieved after 45 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006787	0.002642	2.568451	0.0128
AR(1)	-0.166542	0.079673	-2.090326	0.0409
AR(2)	-0.216600	0.149794	-1.445980	0.1535
AR(3)	-0.192680	0.105779	-1.821538	0.0736
AR(4)	0.736134	0.136078	5.409655	0.0000
SIGMASQ	0.000249	3.64E-05	6.856441	0.0000

R-squared	0.765757	Mean dependent var	0.006735
Adjusted R-squared	0.745906	S.D. dependent var	0.032885
S.E. of regression	0.016577	Akaike info criterion	-5.176943
Sum squared resid	0.016212	Schwarz criterion	-4.976230
Log likelihood	174.2506	Hannan-Quinn criter.	-5.097749
F-statistic	38.57501	Durbin-Watson stat	2.043276
Prob(F-statistic)	0.000000		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

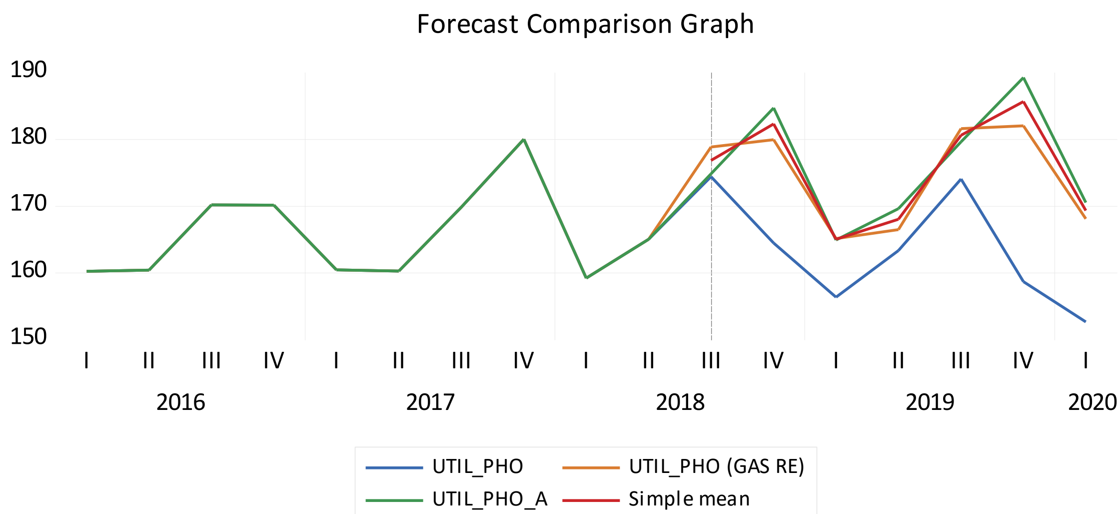
Forecast	F-stat	F-prob
UTIL PHO V	3.722335	0.1116
UTIL PHO A	0.385865	0.5617

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	-1.090769	0.3172	0.1586	0.8414
Sq Error	-1.565720	0.1685	0.0842	0.9158

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL PHO V	13.03059	11.17856	6.957643	6.640920	0.038509	1.385745
UTIL PHO A	16.07758	12.79538	8.010103	7.534994	0.047282	1.716062
Simple mean	14.49804	11.98697	7.483873	7.094289	0.042742	1.547366



Seattle

Vector Error Correction Estimates
Sample (adjusted): 1998Q4 2018Q2
Included observations: 79 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(UTIL_SEA(-1))	1.000000		
LOG(RGAS(-1))	-0.683007		
	(1.75938)		
	[-0.38821]		
LOG(RE(-1))	-43.13133		
	(18.1025)		
	[-2.38262]		
C	306.9067		
R-squared	0.301263	0.228192	0.297041
Adj. R-squared	0.232374	0.152098	0.227735
Sum sq. resids	0.023255	1.998944	0.035534
S.E. equation	0.018098	0.167792	0.022371
F-statistic	4.373133	2.998825	4.285947
Log likelihood	209.0652	33.13859	192.3189
Akaike AIC	-5.090258	-0.636420	-4.666301
Schwarz SC	-4.850314	-0.396476	-4.426357
Mean dependent	0.010436	-0.001753	-0.000388
S.D. dependent	0.020657	0.182221	0.025457

Dependent Variable: DLOG(UTIL SEA)
Method: ARMA Maximum Likelihood (BFGS)
Sample: 1998Q2 2018Q2
Included observations: 81
Convergence achieved after 48 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009701	0.002479	3.913105	0.0002
AR(1)	-0.904571	0.170833	-5.295051	0.0000
AR(2)	-0.958104	0.080775	-11.86140	0.0000
AR(3)	-0.831574	0.167013	-4.979111	0.0000
MA(1)	1.330474	0.218874	6.078712	0.0000
MA(2)	1.208821	0.247569	4.882768	0.0000
MA(3)	0.864688	0.267496	3.232525	0.0019
MA(4)	0.303003	0.138192	2.192629	0.0316
SIGMASQ	0.000261	4.25E-05	6.145313	0.0000

R-squared	0.411031	Mean dependent var	0.009791
Adjusted R-squared	0.345590	S.D. dependent var	0.021190
S.E. of regression	0.017142	Akaike info criterion	-5.161944
Sum squared resid	0.021157	Schwarz criterion	-4.895894
Log likelihood	218.0587	Hannan-Quinn criter.	-5.055201
F-statistic	6.280934	Durbin-Watson stat	1.977945
Prob(F-statistic)	0.000004		

Forecast Evaluation
Sample: 2018Q3 2020Q1
Included observations: 7
Evaluation sample: 2018Q3 2020Q1
Number of forecasts: 3

Combination tests
Null hypothesis: Forecast i includes all information contained in others

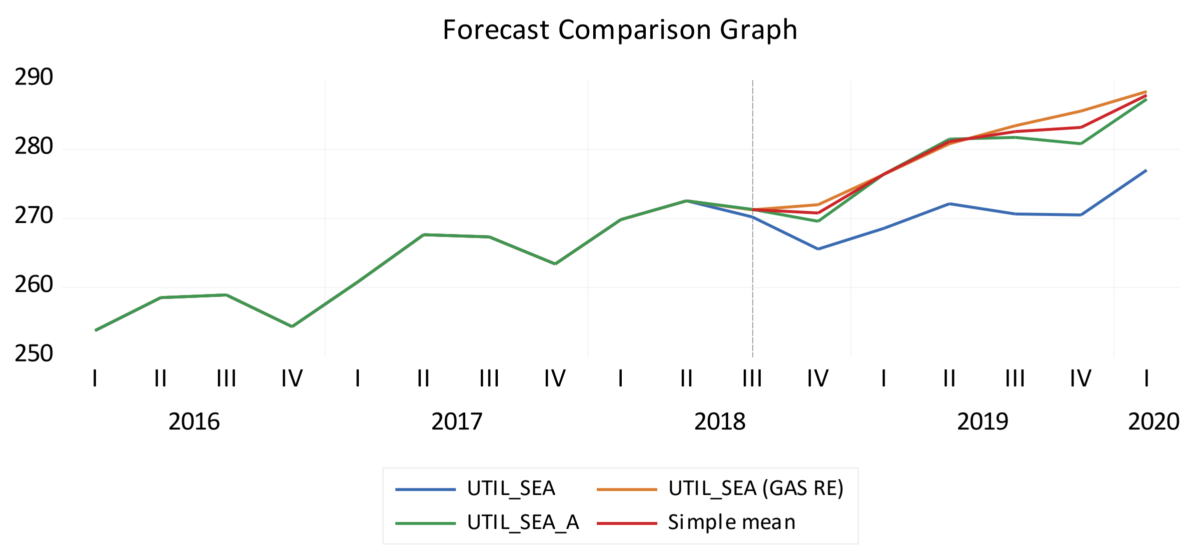
Forecast	F-stat	F-prob
UTIL_SEA_V	5.985870	0.0582
UTIL_SEA_A	22.61483	0.0051

Diebold-Mariano test (HLN adjusted)
Null hypothesis: Both forecasts have the same accuracy

Accuracy	Statistic	<> prob	> prob	< prob
Abs Error	1.874945	0.1099	0.9450	0.0550
Sq Error	1.681786	0.1436	0.9282	0.0718

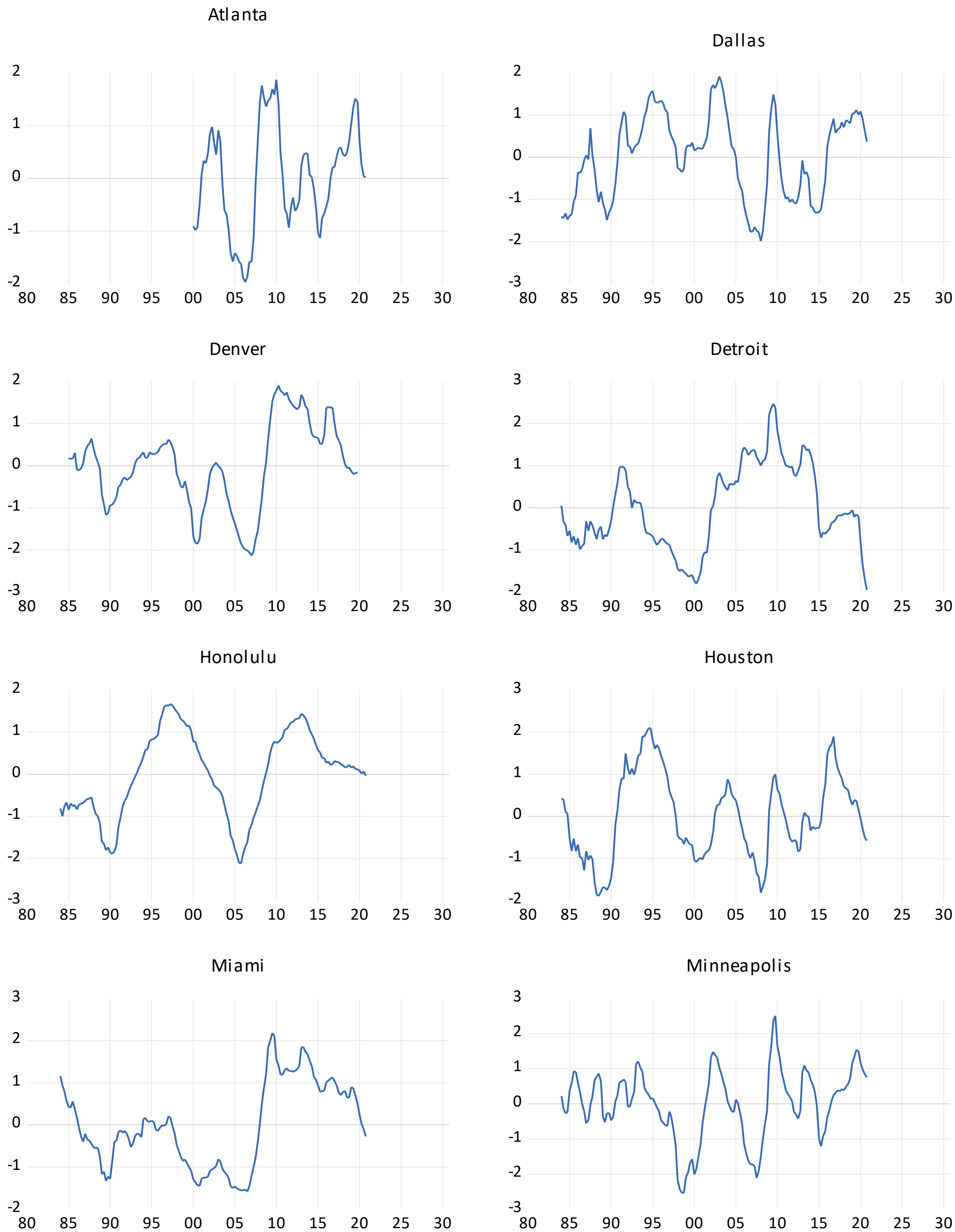
Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
UTIL_SEA_V	9.982453	9.021538	3.327277	3.261092	0.018136	2.812011
UTIL_SEA_A	8.456982	7.708422	2.840637	2.793068	0.015401	2.383774
Simple mean	9.187936	8.364980	3.083957	3.027834	0.016712	2.588910

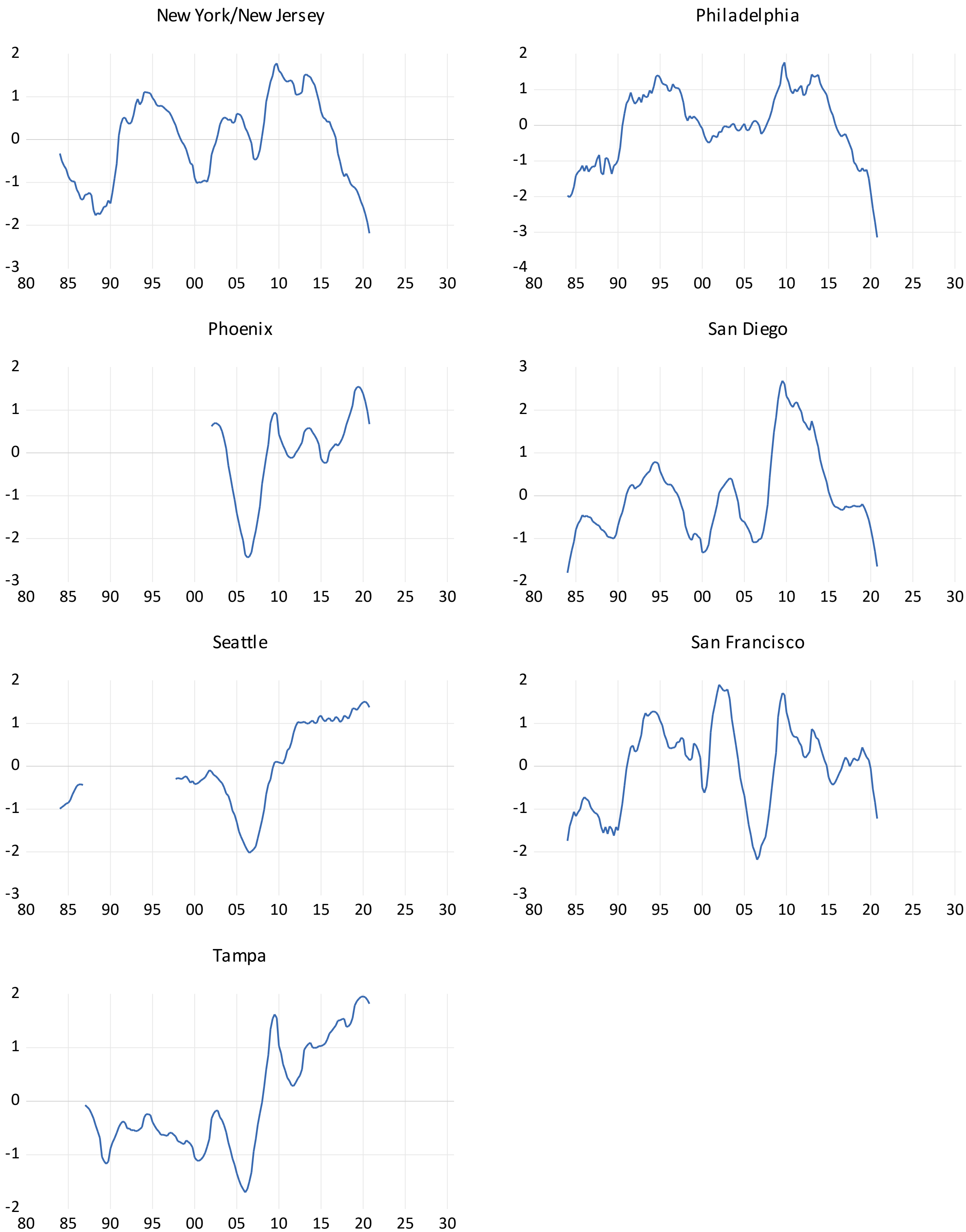


Appendix B: Summary of Rapidly Rising Rent Analysis

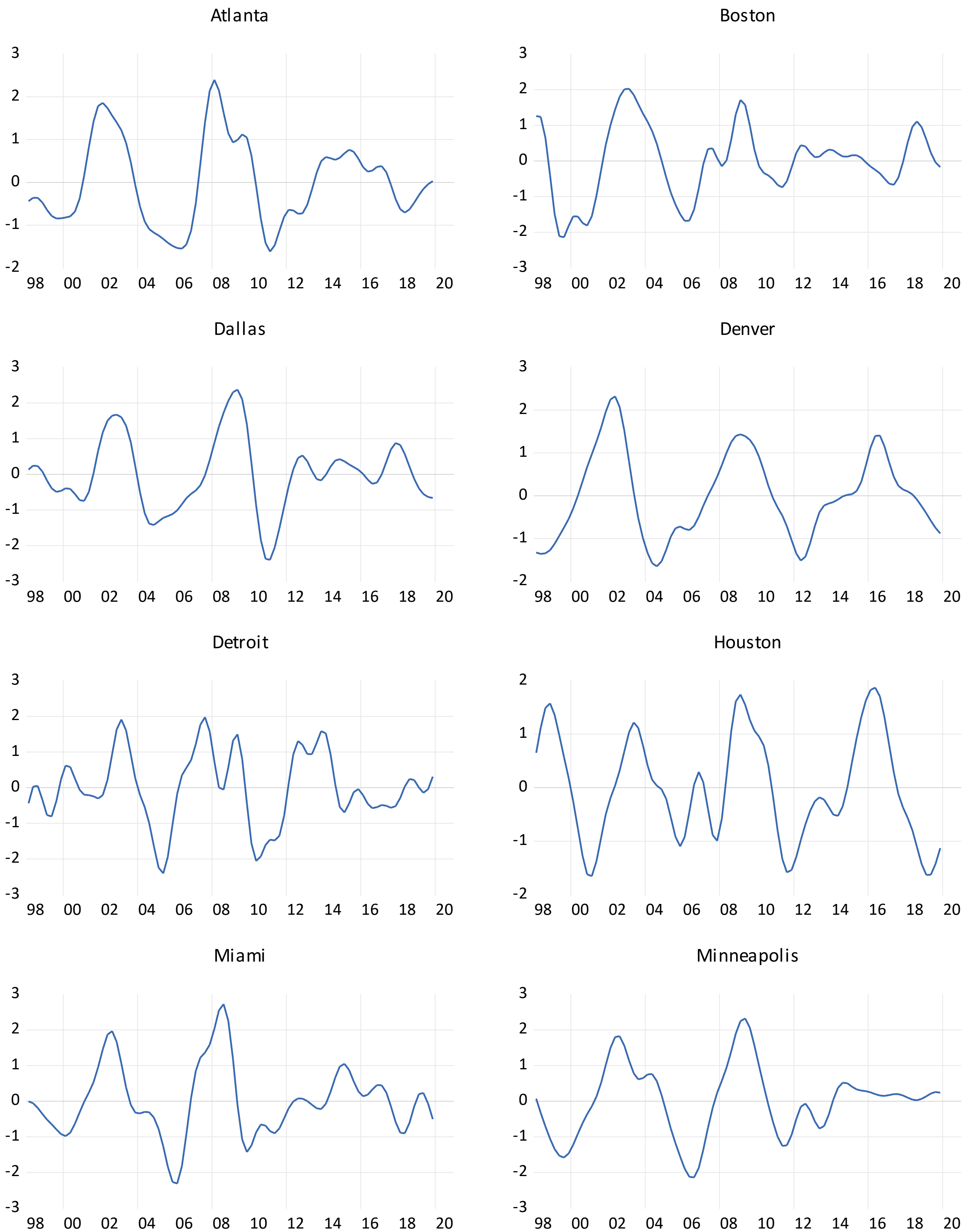
Error-Correction Residual (Normalized Scaling)



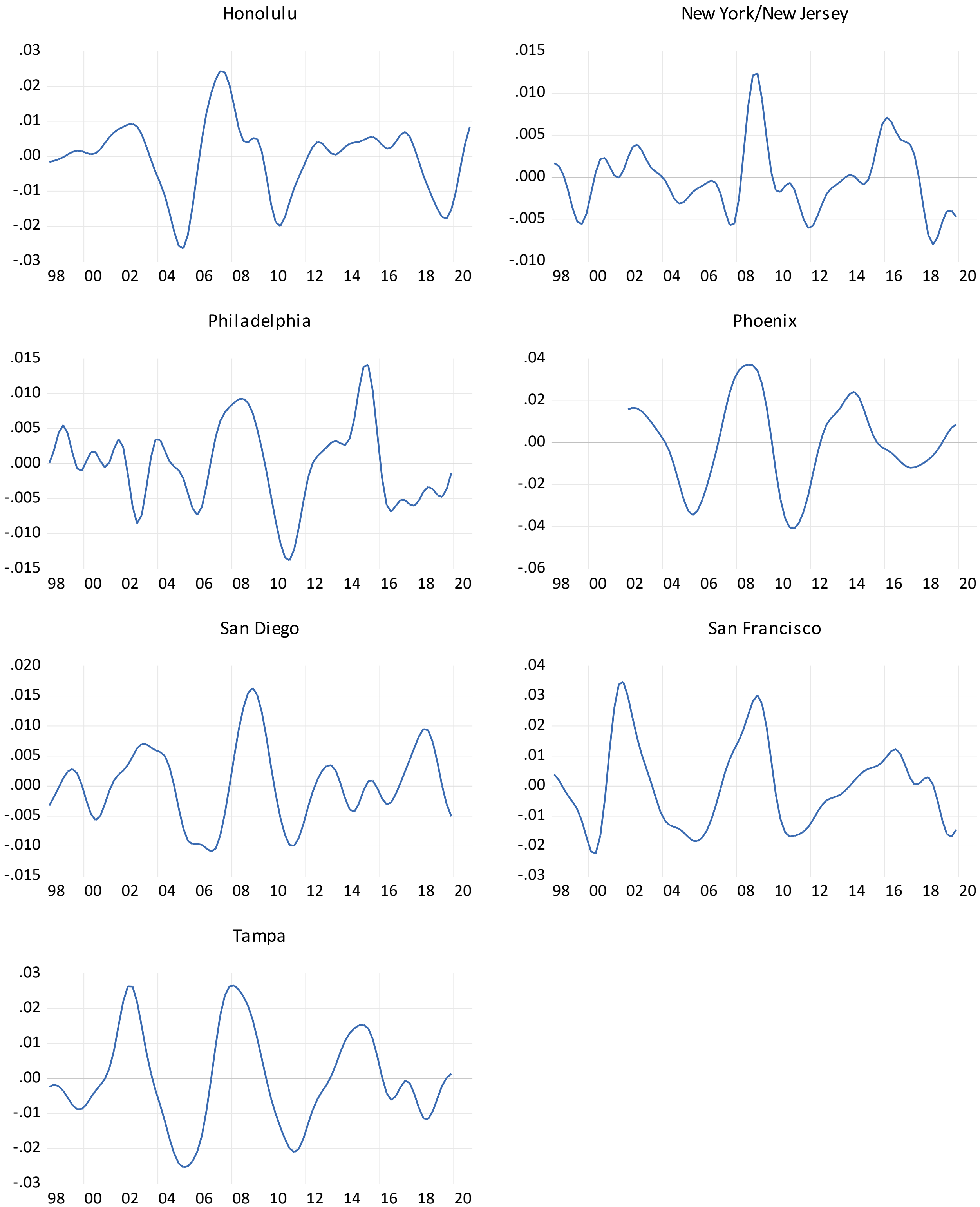
Error-Correction Residual (Normalized Scaling)



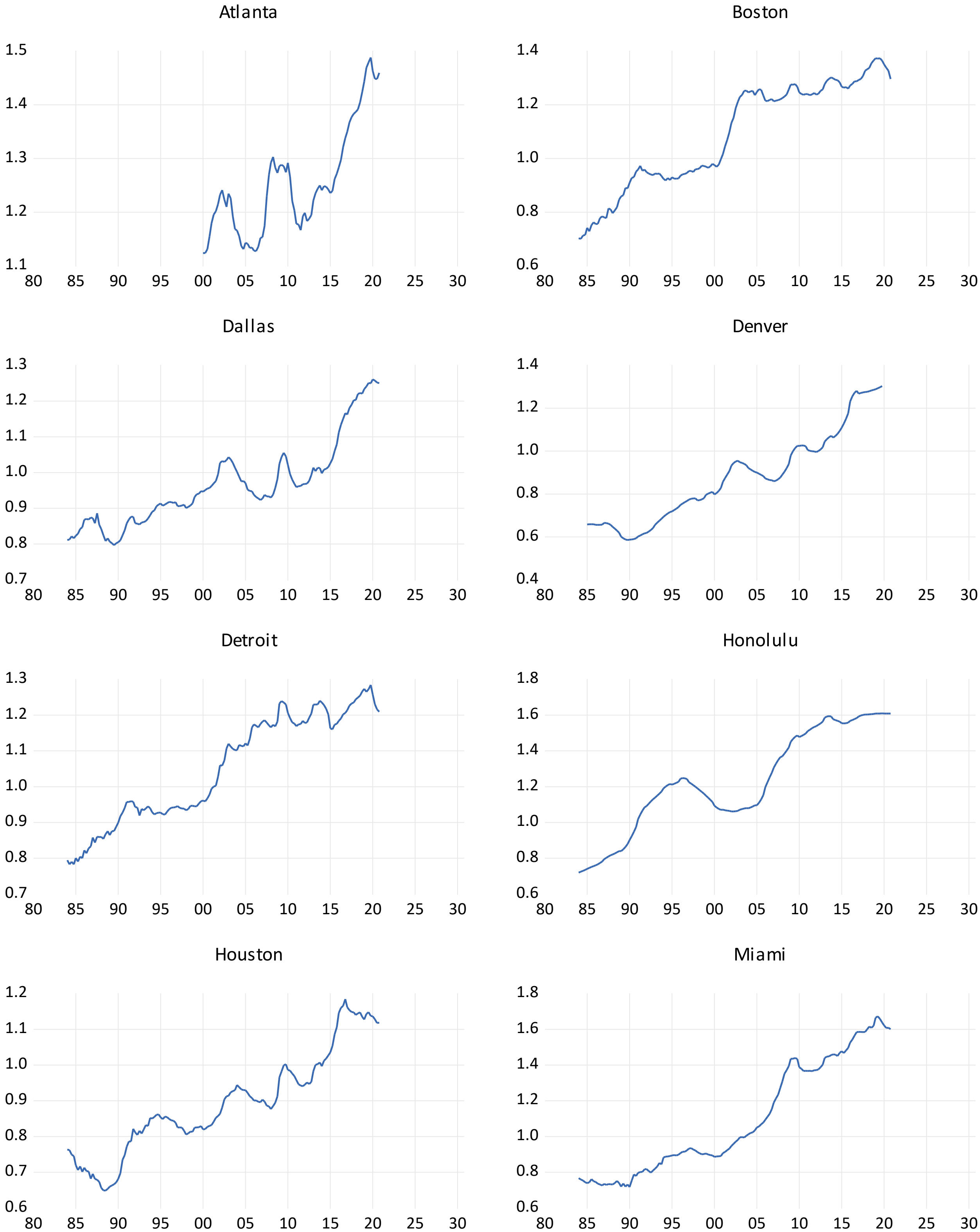
Band-Pass Filter 2-8 Year Component (Normalized Scaling)



Band-Pass Filter 2-8 Year Component (Normalized Scaling)

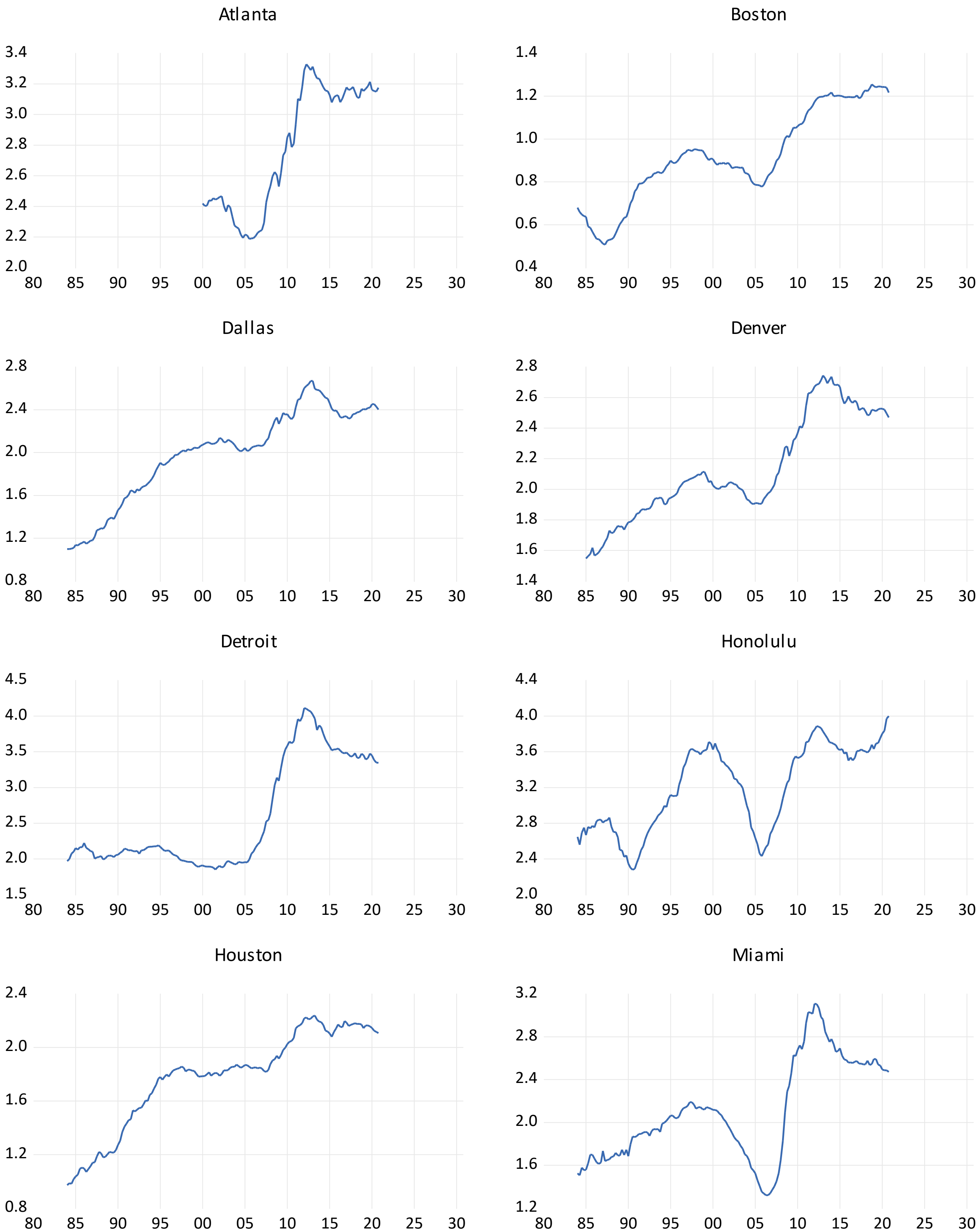


Rent-to-Real Income Ratio

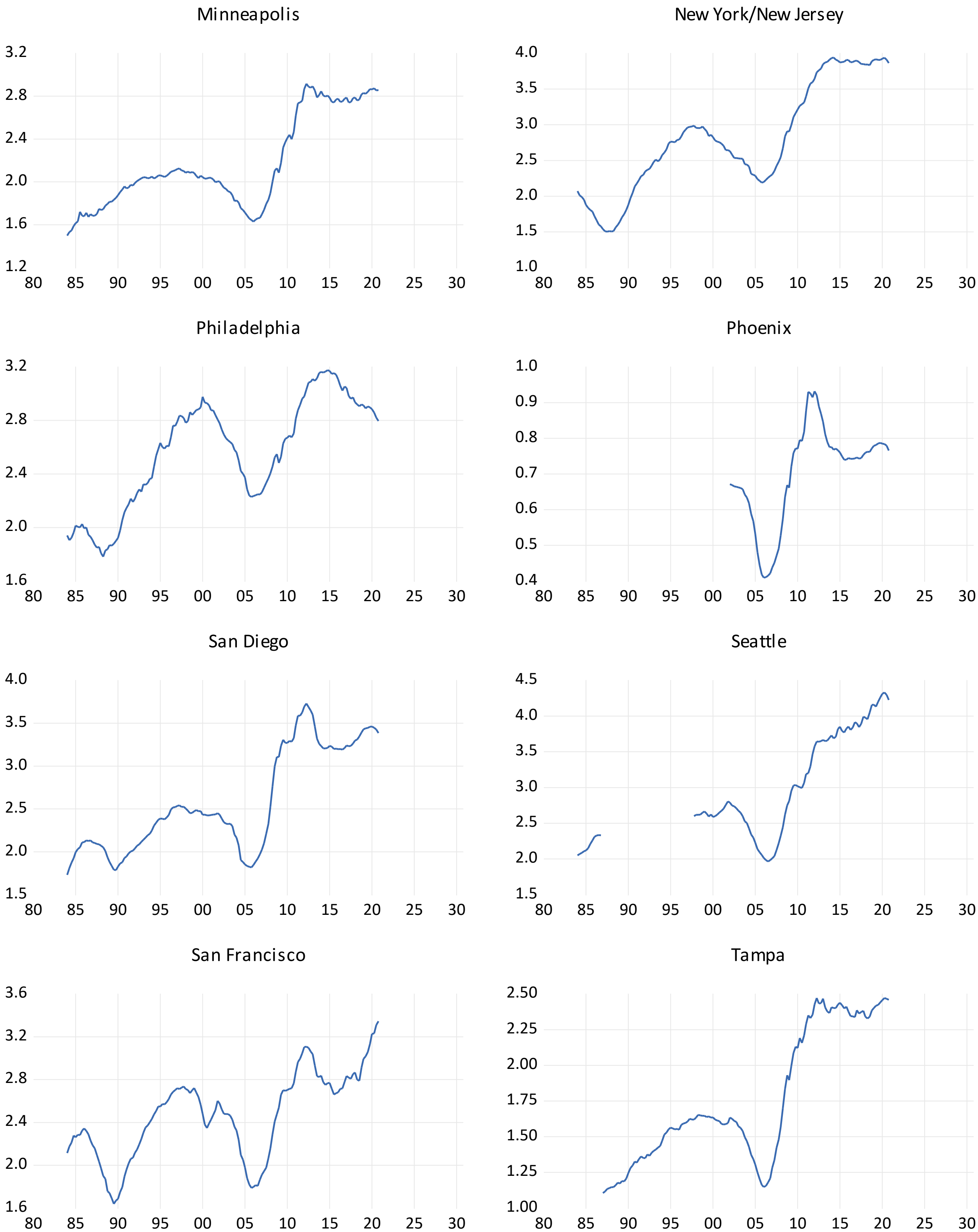


Rent-to-Real Income Ratio

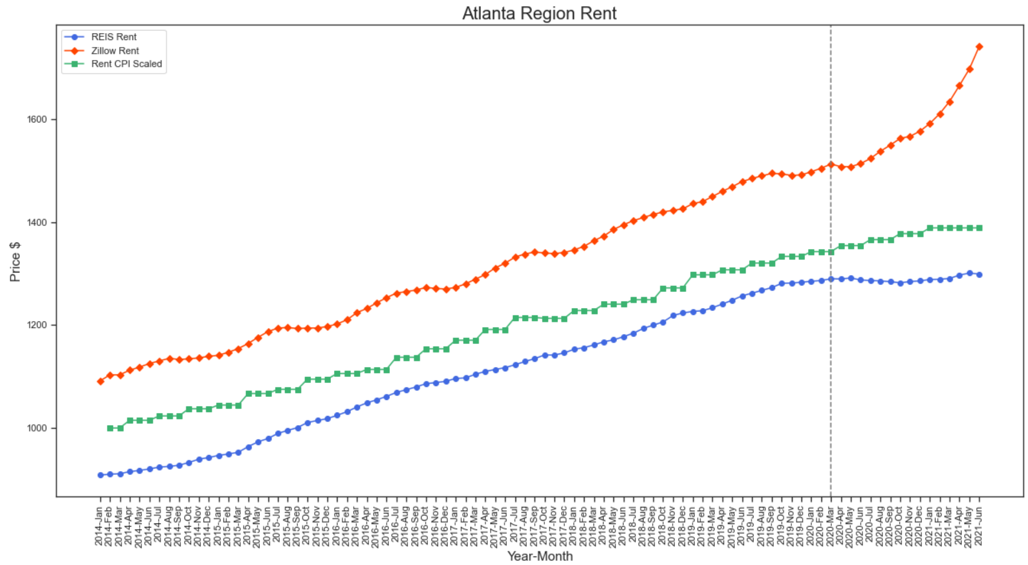
Rent-to-Real Home Price Ratio

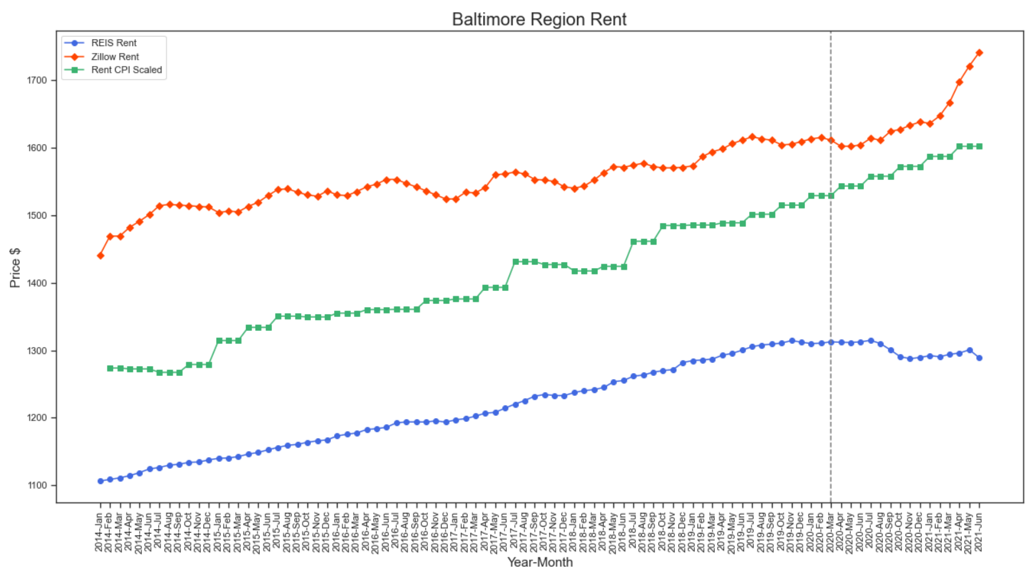


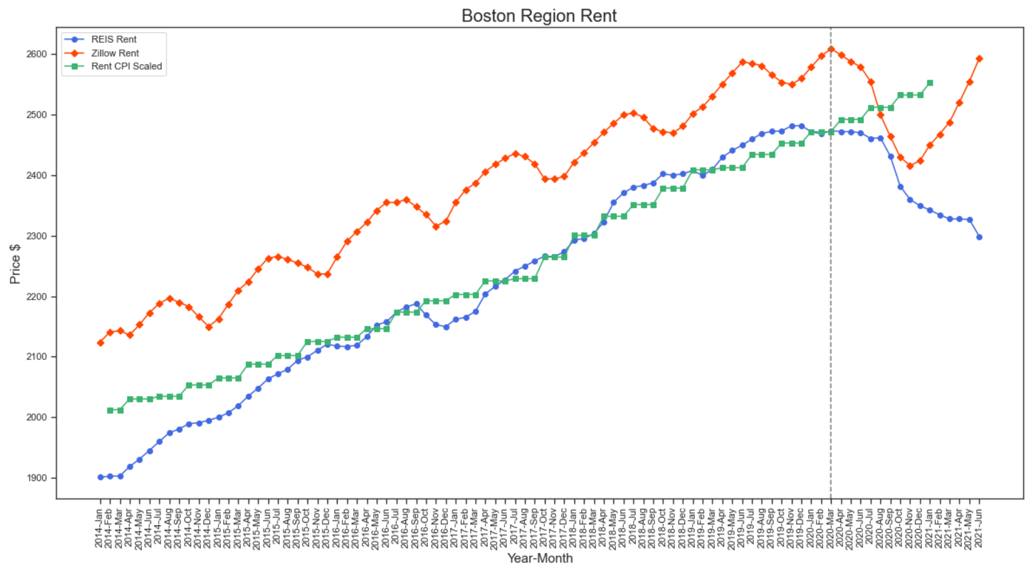
Rent-to-Real Home Price Ratio

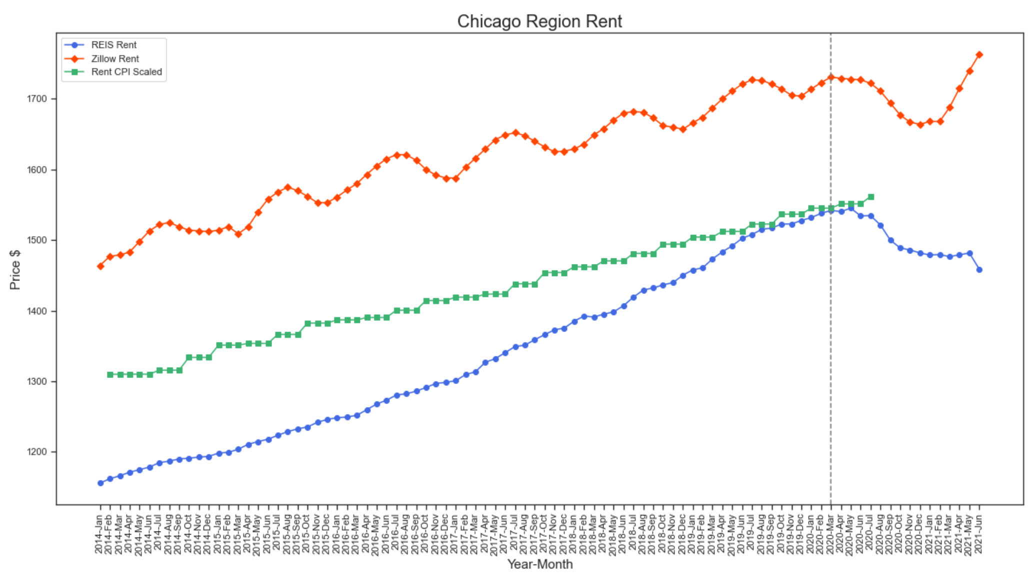


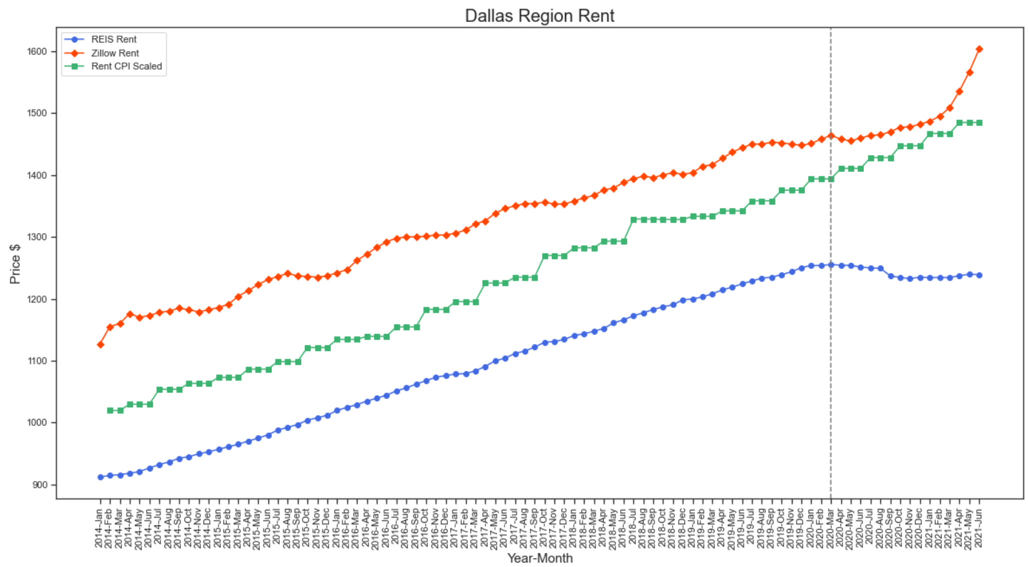
Appendix C: Alternative Data Set Analysis

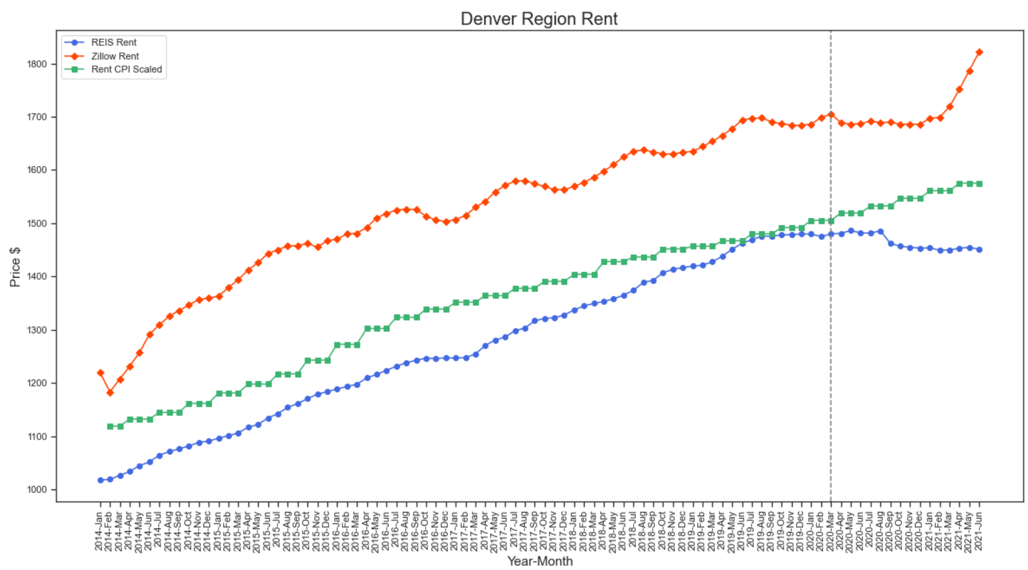


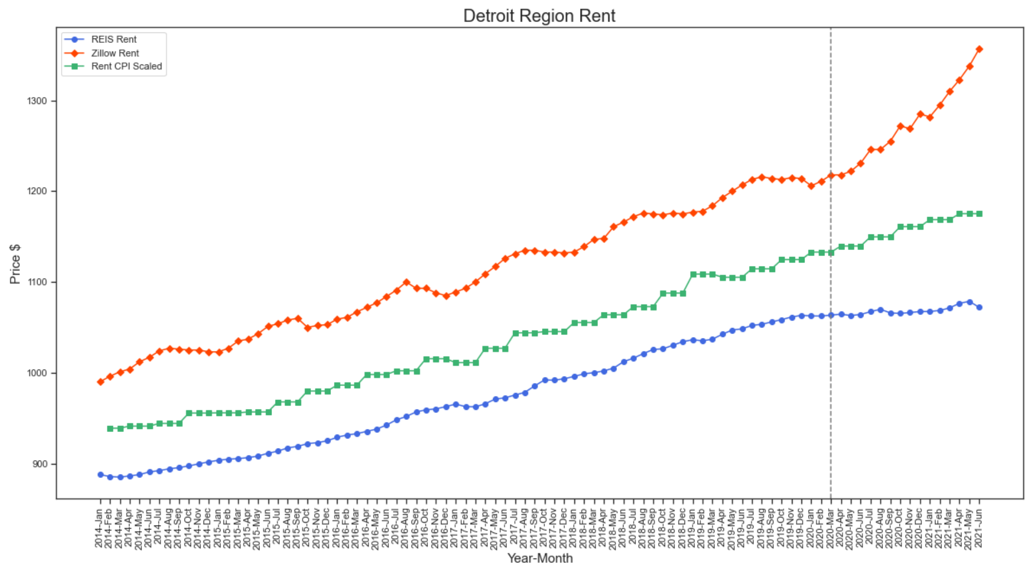


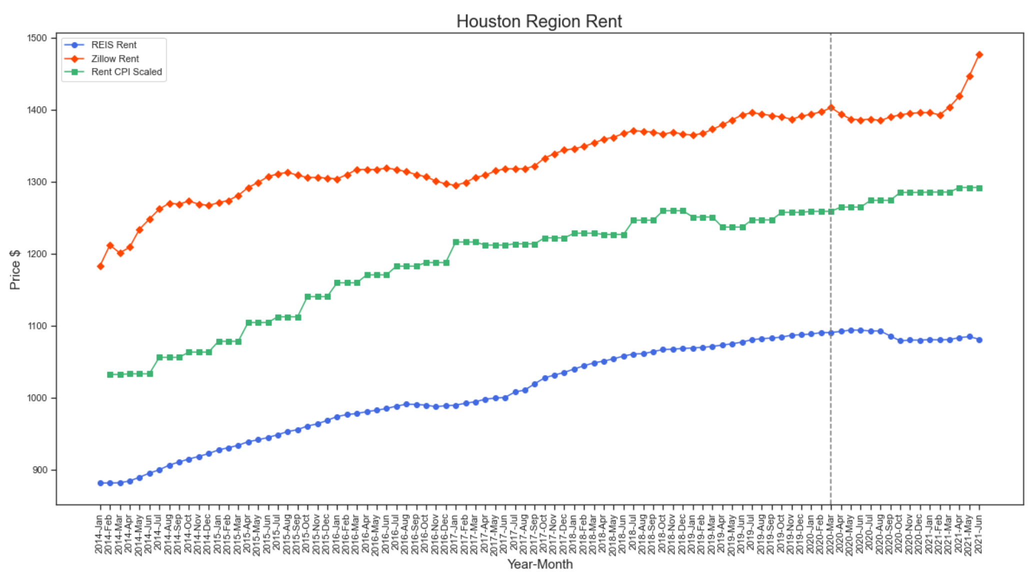

Boston Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
2600
2500
2400
2300
2200
2100
2000
1900
Year-Month

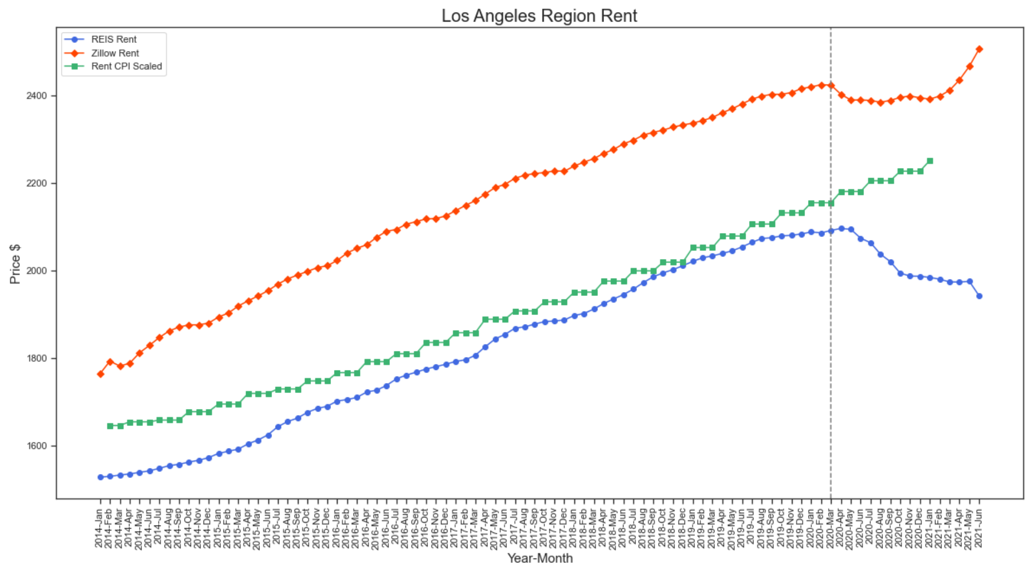

Chicago Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
1700
1600
1500
1400
1300
1200
Year-Month

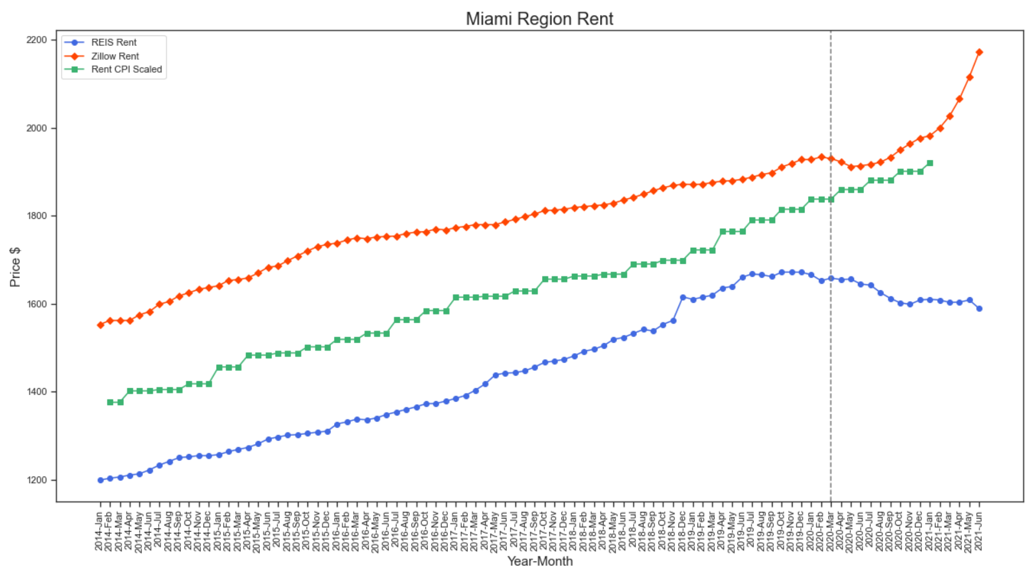

Dallas Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

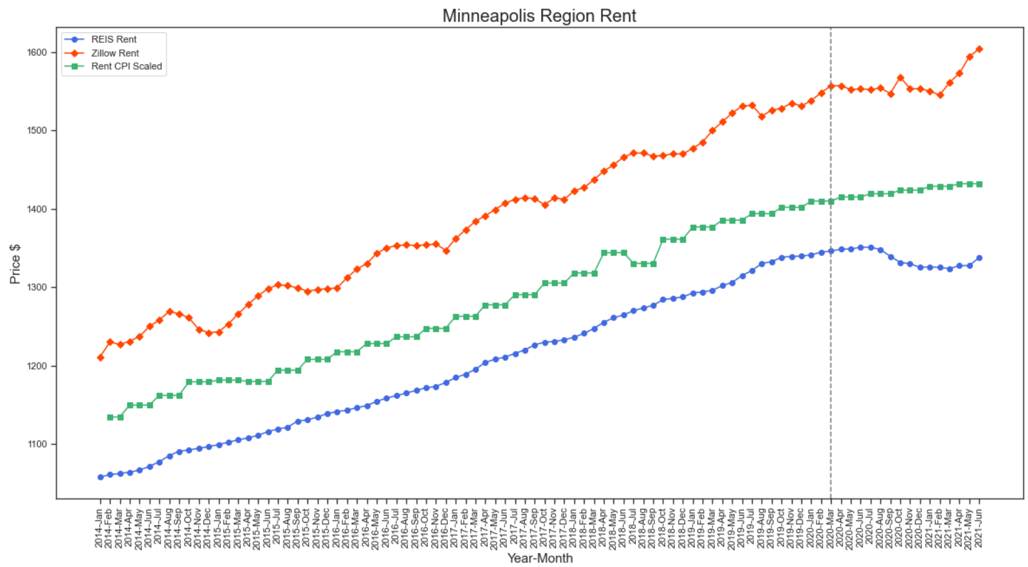

Denver Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

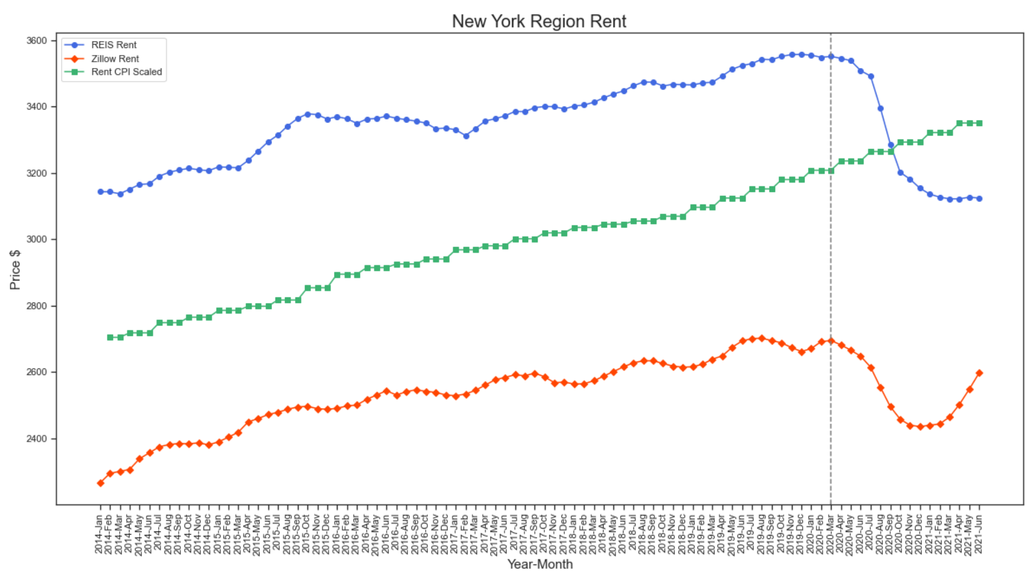

Detroit Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

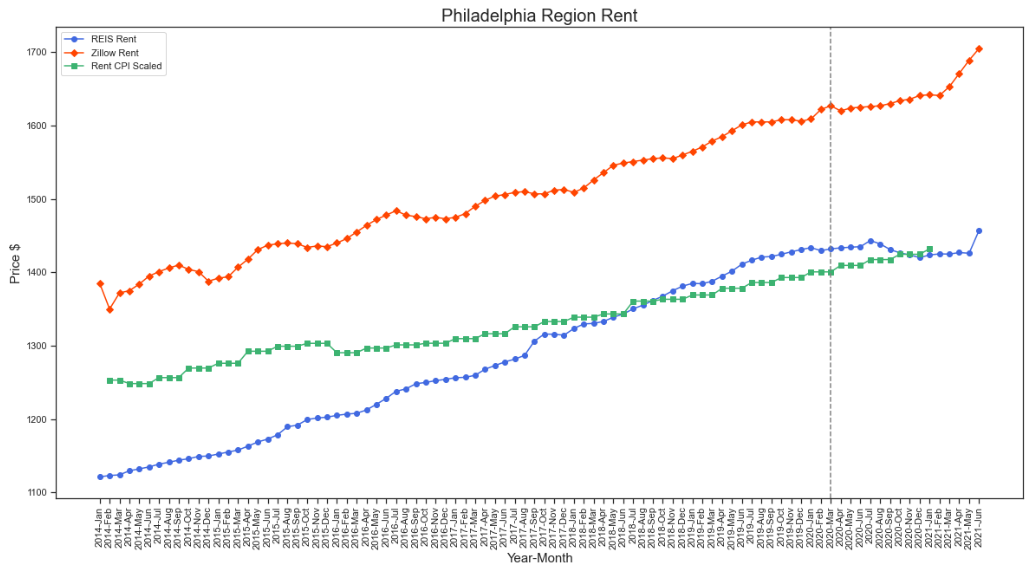

Houston Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

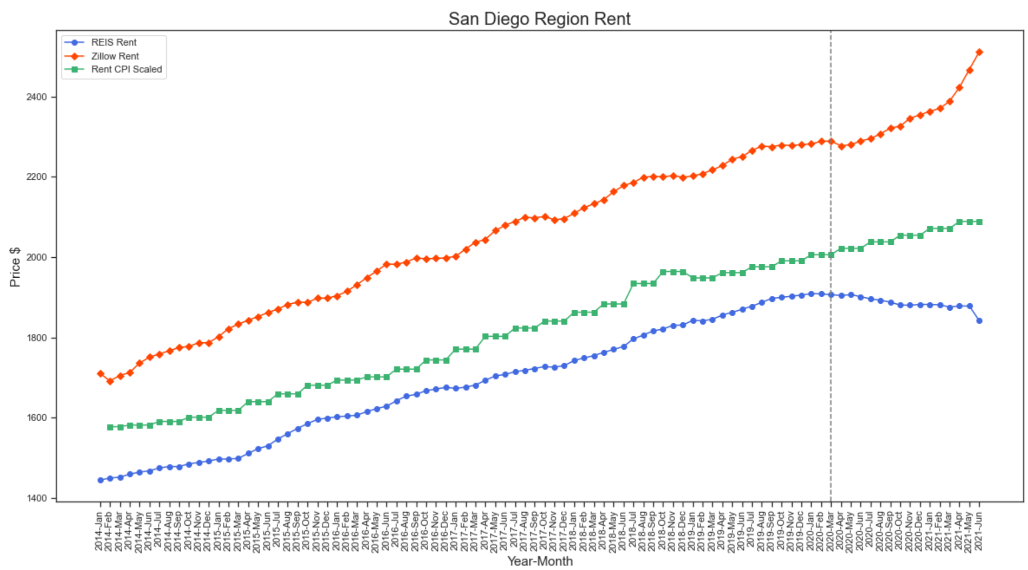

Los Angeles Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

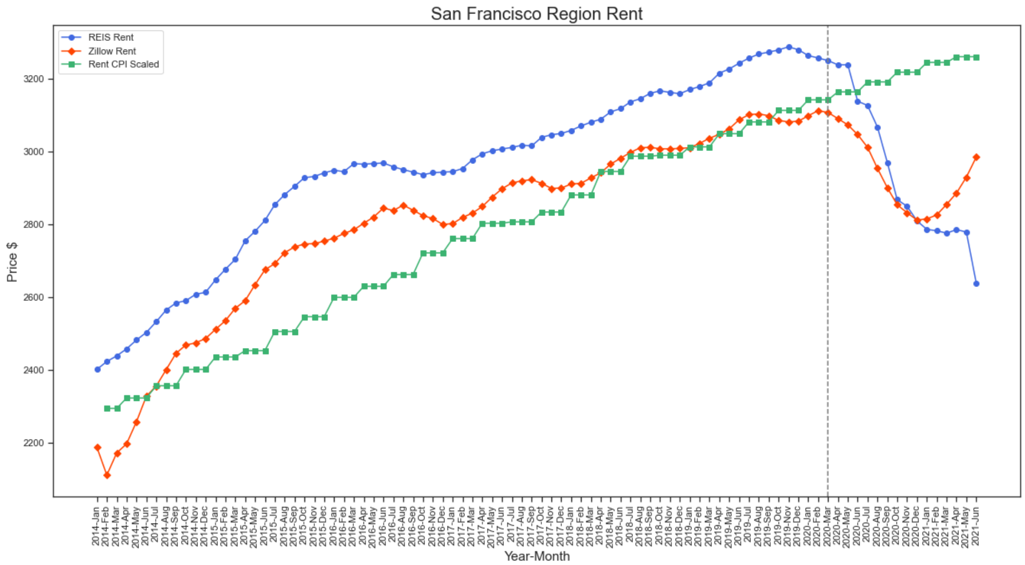

Miami Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

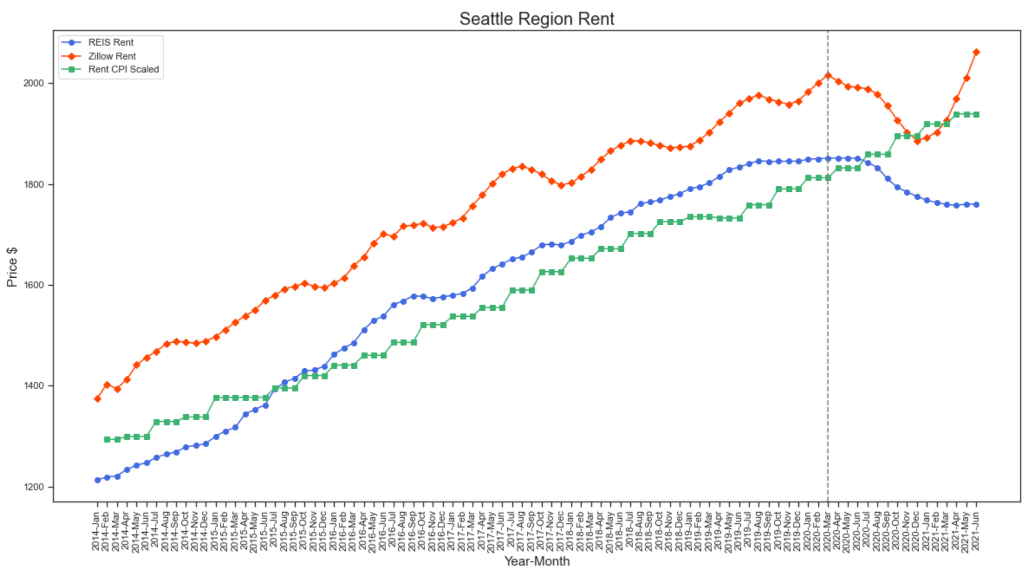

Minneapolis Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

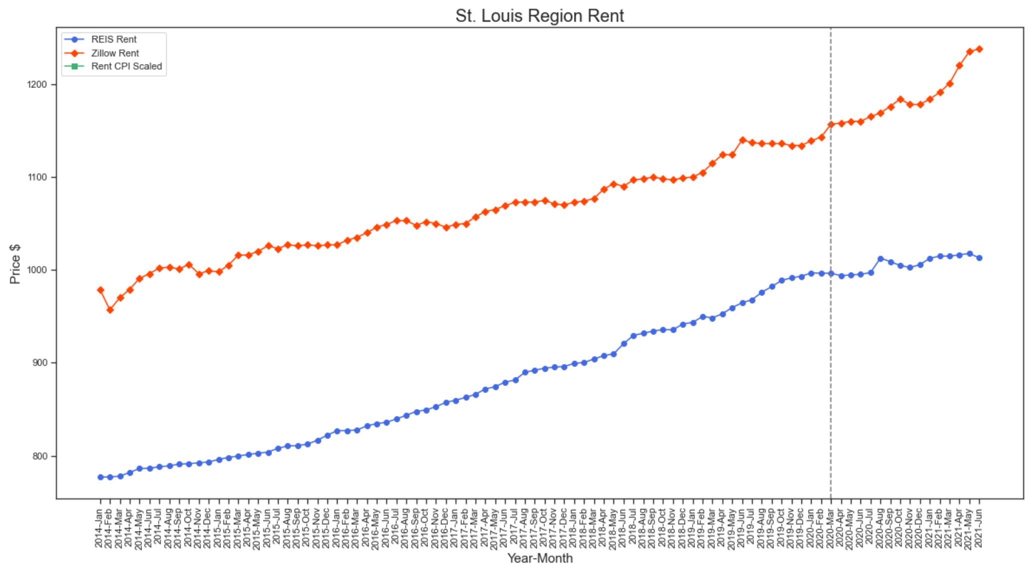

New York Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

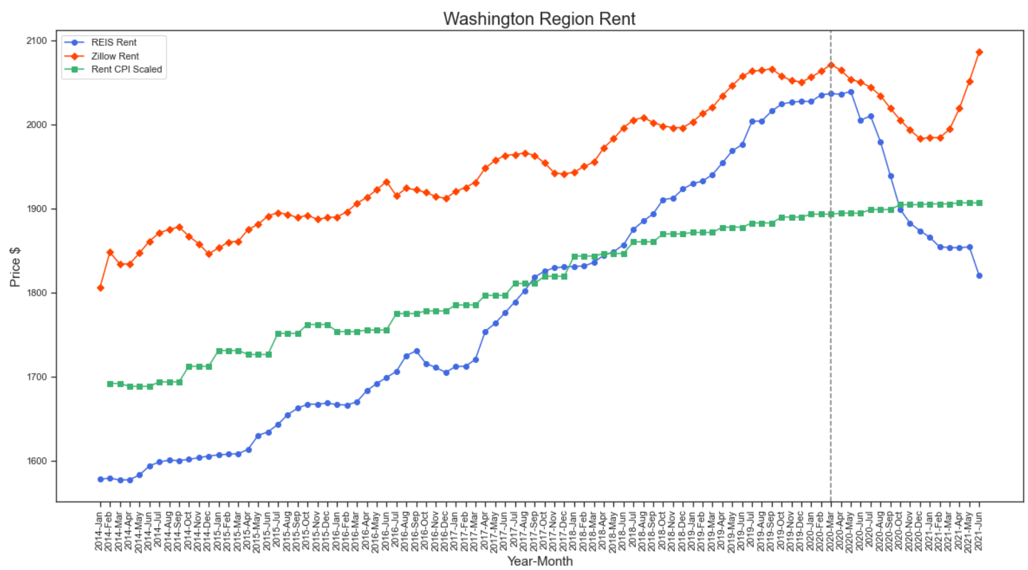

Philadelphia Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month


San Diego Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month


San Francisco Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month


Seattle Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month


St. Louis Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month


Washington Region Rent
REIS Rent
Zillow Rent
Rent CPI Scaled
Price $
Year-Month

Appendix D: Summary of Augmented Dickey-Fuller Tests

Null Hypothesis: Unit root (individual unit root process)
Sample: 2014M01 2021M12
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 6
Total (balanced) observations: 2112
Cross-sections included: 24

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	5.81046	1.0000

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Series	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
CUSR0000S...	-1.2201	0.6628	-1.505	0.769	3	11	88
CUUR0100S...	-1.3569	0.5998	-1.527	0.748	1	11	88
CUUR0200S...	1.5029	0.9992	-1.527	0.748	1	11	88
CUUR0300S...	-0.9573	0.7652	-1.529	0.735	0	11	88
CUUR0400S...	-0.8102	0.8111	-1.527	0.748	1	11	88
CUURA100...	-2.1808	0.2147	-1.529	0.735	0	11	88
CUURA101...	-2.6276	0.0913	-1.529	0.735	0	11	88
CUURA102...	0.2708	0.9755	-1.529	0.735	0	11	88
CUURA103...	-0.2552	0.9261	-1.529	0.735	0	11	88
CUURA200...	1.0699	0.9970	-1.527	0.748	1	11	88
CUURA208...	0.8333	0.9941	-1.463	0.811	6	11	88
CUURA300...	-3.0029	0.0385	-1.529	0.735	0	11	88
CUURA316...	-1.0527	0.7312	-1.529	0.735	0	11	88
CUURA318...	-3.3745	0.0145	-1.529	0.735	0	11	88
CUURA319...	0.2999	0.9771	-1.529	0.735	0	11	88
CUURA320...	-2.6337	0.0901	-1.529	0.735	0	11	88
CUURA400...	-1.4994	0.5294	-1.508	0.759	2	11	88
CUURA422...	-3.0579	0.0336	-1.529	0.735	0	11	88
CUURA423...	-1.8851	0.3378	-1.529	0.735	0	11	88
CUURX000...	2.4050	1.0000	-1.527	0.748	1	11	88
CUURX100...	2.1279	0.9999	-1.529	0.735	0	11	88
CUURX200...	2.1013	0.9999	-1.529	0.735	0	11	88
CUURX300...	1.5198	0.9993	-1.529	0.735	0	11	88
CUURX400...	1.7590	0.9997	-1.529	0.735	0	11	88
Average	-0.5010		-1.524	0.744			

Appendix E: Rapidly Rising Rents Dashboard

D = Decreasing at a decreasing rate. R = Increasing at a decreasing rate. RD = Decreasing at an increasing rate. RR = Increasing at an increasing rate.

Alaska	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RR	RR	RR
1995Q3	RR	RR	RR
1995Q4	R	RR	R
1996Q1	RR	RR	RR
1996Q2	R	R	R
1996Q3	RR	R	RR
1996Q4	RD	R	RD
1997Q1	RD	RD	RD
1997Q2	D	RD	D
1997Q3	D	RD	RR
1997Q4	RD	RD	RD
1998Q1	RD	D	RD
1998Q2	D	D	D
1998Q3	RD	D	RD
1998Q4	D	RR	RR
1999Q1	RR	RR	RR
1999Q2	RD	R	RD
1999Q3	RD	R	RD
1999Q4	D	RD	D
2000Q1	RD	RD	RD
2000Q2	D	RD	D
2000Q3	RD	D	RD
2000Q4	D	D	D
2001Q1	RR	RR	RR
2001Q2	R	RR	RR
2001Q3	R	RR	RR
2001Q4	RR	RR	RR
2002Q1	RR	RR	RR
2002Q2	R	R	R
2002Q3	R	R	R
2002Q4	R	R	RR
2003Q1	R	R	R
2003Q2	RR	RD	RR
2003Q3	RR	RD	RR
2003Q4	R	RD	R
2004Q1	R	RD	R
2004Q2	RD	RD	RD
2004Q3	RR	RD	RD

2004Q4	RD	D	RD
2005Q1	RD	D	RD
2005Q2	RR	D	RR
2005Q3	RR	RR	RR
2005Q4	R	RR	R
2006Q1	RD	RR	R
2006Q2	RD	R	RD
2006Q3	RD	R	RD
2006Q4	RD	R	RD
2007Q1	D	RD	RD
2007Q2	D	RR	D
2007Q3	D	RR	RR
2007Q4	RD	RR	RD
2008Q1	RD	RR	RD
2008Q2	RR	RR	RR
2008Q3	RR	R	RR
2008Q4	R	R	R
2009Q1	RR	R	RR
2009Q2	R	RD	R
2009Q3	RR	RD	RR
2009Q4	R	D	R
2010Q1	RD	D	RD
2010Q2	D	RD	D
2010Q3	RD	RD	D
2010Q4	D	RD	RR
2011Q1	D	RD	RR
2011Q2	D	RD	R
2011Q3	RD	D	RD
2011Q4	RR	D	RR
2012Q1	RR	D	RR
2012Q2	RR	RR	RR
2012Q3	RR	RR	RR
2012Q4	RR	RR	RR
2013Q1	RR	RR	RR
2013Q2	R	RR	R
2013Q3	R	RR	R
2013Q4	RD	RR	R
2014Q1	RD	RR	RD
2014Q2	D	RR	D
2014Q3	RR	R	RR
2014Q4	RD	R	R
2015Q1	RD	R	RD
2015Q2	D	RD	D
2015Q3	D	RD	RD
2015Q4	RR	RD	RR

2016Q1	RR	RD	RR
2016Q2	R	RD	R
2016Q3	RR	RD	RR
2016Q4	RD	RD	RD
2017Q1	RD	RD	RD
2017Q2	D	D	D
2017Q3	RD	D	D
2017Q4	D	RR	D
2018Q1	RD	RR	RD
2018Q2	D	RR	D
2018Q3	RR	R	RR
2018Q4	RD	R	R
2019Q1	RD	RD	RD
2019Q2	D	RD	D
2019Q3	RD	RD	RD
2019Q4	RD	RD	RD
2020Q1	RD	D	RD
2020Q2	RR	RR	RD
2020Q3	RD	RD	D
2020Q4	RD	RD	RD

Atlanta	Error-Correction	Band-Pass	Income
2000Q1	RD	RR	RR
2000Q2	D	RR	R
2000Q3	RR	RR	RR
2000Q4	RR	RR	RR
2001Q1	RR	RR	RR
2001Q2	R	RR	R
2001Q3	RD	R	R
2001Q4	RR	R	RR
2002Q1	RR	R	RR
2002Q2	R	RD	R
2002Q3	RD	RD	RD
2002Q4	D	D	D
2003Q1	RR	RD	RR
2003Q2	RD	RD	RD
2003Q3	RD	RD	RD
2003Q4	D	RD	D
2004Q1	D	D	D
2004Q2	RD	D	RD

2004Q3	RD	D	RD
2004Q4	D	D	D
2005Q1	RR	D	RR
2005Q2	RD	RD	RD
2005Q3	RD	RD	RD
2005Q4	D	D	RR
2006Q1	RD	D	RD
2006Q2	D	D	D
2006Q3	RR	RR	RR
2006Q4	RR	RR	RR
2007Q1	R	RR	R
2007Q2	RR	RR	RR
2007Q3	RR	RR	RR
2007Q4	R	R	R
2008Q1	R	R	R
2008Q2	R	RD	R
2008Q3	RD	RD	RD
2008Q4	D	D	D
2009Q1	RR	D	RR
2009Q2	R	RR	R
2009Q3	RR	RR	RD
2009Q4	RD	RD	RD
2010Q1	RR	RD	RR
2010Q2	RD	RD	RD
2010Q3	RD	RD	RD
2010Q4	D	D	D
2011Q1	RD	D	RD
2011Q2	D	RR	D
2011Q3	RD	RR	RD
2011Q4	RR	R	RR
2012Q1	R	R	R
2012Q2	RD	RD	RD
2012Q3	RR	RD	RR
2012Q4	RR	RR	RR
2013Q1	RR	RR	RR
2013Q2	R	RR	R
2013Q3	R	RR	R
2013Q4	RD	R	R
2014Q1	RD	R	RD
2014Q2	D	RD	RR
2014Q3	RD	RD	RD
2014Q4	RD	RR	RD
2015Q1	RD	RR	RD
2015Q2	D	R	RR
2015Q3	RR	RD	RR

2015Q4	R	RD	R
2016Q1	RR	RD	RR
2016Q2	RR	D	RR
2016Q3	RR	RR	RR
2016Q4	R	RR	R
2017Q1	R	R	R
2017Q2	RR	RD	RR
2017Q3	R	RD	R
2017Q4	R	RD	R
2018Q1	RD	D	R
2018Q2	D	D	RR
2018Q3	RR	RR	RR
2018Q4	RR	RR	RR
2019Q1	RR	RR	R
2019Q2	R	R	RR
2019Q3	R	R	R
2019Q4	RD	R	R
2020Q1	RD	R	RD
2020Q2	D	RD	D
2020Q3	D	RD	D
2020Q4	D	RD	RR

Baltimore	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RD
1995Q3	RD	RD	RD
1995Q4	RD	RD	RD
1996Q1	RD	RD	RD
1996Q2	RD	RD	RD
1996Q3	RD	RD	RD
1996Q4	RD	RD	RD
1997Q1	RD	RD	RD
1997Q2	RD	RD	RD
1997Q3	RD	RD	RD
1997Q4	RD	RD	RD
1998Q1	RR	RR	RR
1998Q2	RD	R	RD
1998Q3	D	R	RR
1998Q4	D	R	RR
1999Q1	D	RD	R
1999Q2	RD	RD	R
1999Q3	RD	RD	RD

1999Q4	RD	D	D
2000Q1	RD	D	RD
2000Q2	D	D	D
2000Q3	D	RR	RR
2000Q4	RR	RR	RR
2001Q1	RR	RR	RR
2001Q2	R	R	R
2001Q3	RD	R	RR
2001Q4	RD	R	RR
2002Q1	RR	R	RR
2002Q2	RR	RR	RR
2002Q3	R	RR	R
2002Q4	RR	RR	RR
2003Q1	RR	R	RR
2003Q2	RD	R	R
2003Q3	RR	R	RR
2003Q4	RR	RD	RR
2004Q1	RD	RD	RD
2004Q2	D	RD	RD
2004Q3	RR	RD	RR
2004Q4	RR	RD	RR
2005Q1	R	D	R
2005Q2	RD	D	R
2005Q3	RR	D	RR
2005Q4	R	RR	R
2006Q1	RD	RR	R
2006Q2	RR	RR	RR
2006Q3	RR	RR	RR
2006Q4	RD	R	R
2007Q1	RR	R	RR
2007Q2	R	RD	R
2007Q3	RD	RD	RR
2007Q4	RR	D	RR
2008Q1	RD	D	RD
2008Q2	RR	RR	RR
2008Q3	RR	RR	RR
2008Q4	RD	RR	RD
2009Q1	RR	R	RR
2009Q2	R	R	R
2009Q3	R	RD	R
2009Q4	R	RD	R
2010Q1	RD	RD	RD
2010Q2	RD	RD	D
2010Q3	D	D	RD
2010Q4	D	D	RR

2011Q1	RD	D	RD
2011Q2	RR	RR	RR
2011Q3	R	RR	R
2011Q4	RR	RR	RR
2012Q1	R	RR	R
2012Q2	R	R	R
2012Q3	RR	R	RR
2012Q4	RR	R	RR
2013Q1	RR	RD	RR
2013Q2	RD	RD	RD
2013Q3	RR	RD	RR
2013Q4	RR	D	RR
2014Q1	RD	D	RD
2014Q2	D	RR	RD
2014Q3	RD	RR	RR
2014Q4	RD	RR	RR
2015Q1	RD	R	RD
2015Q2	RR	R	RR
2015Q3	RD	R	RD
2015Q4	RD	RD	RD
2016Q1	D	RD	D
2016Q2	RR	RD	RR
2016Q3	RD	D	RR
2016Q4	D	D	R
2017Q1	RR	RR	RR
2017Q2	R	RR	RR
2017Q3	RD	RR	RD
2017Q4	D	R	RD
2018Q1	RR	R	RR
2018Q2	RR	R	RR
2018Q3	R	R	R
2018Q4	RD	RD	RD
2019Q1	D	RD	RR
2019Q2	RD	RD	RD
2019Q3	RD	RD	D
2019Q4	D	D	D
2020Q1	RD	D	RD
2020Q2	RR	RR	RD
2020Q3	RD	RD	D
2020Q4	RD	RD	RD
Boston	Error-Correction	Band-Pass	Income

1995Q1	D	D	D
1995Q2	RD	RR	RD
1995Q3	D	R	RR
1995Q4	D	RR	R
1996Q1	RR	RR	RR
1996Q2	R	RR	R
1996Q3	RD	R	R
1996Q4	D	R	RR
1997Q1	RR	RD	RR
1997Q2	RD	RD	RD
1997Q3	RD	D	RD
1997Q4	RR	D	RR
1998Q1	RD	RR	R
1998Q2	D	RD	RR
1998Q3	D	RD	RR
1998Q4	RD	RD	RD
1999Q1	D	RD	RD
1999Q2	RD	D	RD
1999Q3	D	D	RR
1999Q4	D	RR	RR
2000Q1	RD	R	RD
2000Q2	D	RD	RD
2000Q3	D	RD	RR
2000Q4	RR	D	RR
2001Q1	RR	RR	R
2001Q2	RR	RR	RR
2001Q3	R	RR	R
2001Q4	RR	R	RR
2002Q1	RR	R	RR
2002Q2	R	R	R
2002Q3	RR	R	RR
2002Q4	R	R	R
2003Q1	R	R	R
2003Q2	R	RD	R
2003Q3	RR	RD	RR
2003Q4	RD	D	R
2004Q1	RD	D	RD
2004Q2	D	RD	RR
2004Q3	RD	RD	R
2004Q4	RD	RD	RD
2005Q1	RR	RD	RR
2005Q2	R	D	R
2005Q3	RD	D	RD
2005Q4	RD	D	RD
2006Q1	RD	D	D

2006Q2	D	RR	D
2006Q3	D	RR	RR
2006Q4	RD	RR	R
2007Q1	RD	RR	RD
2007Q2	RR	R	RR
2007Q3	RR	R	RR
2007Q4	R	RD	RR
2008Q1	RR	D	RR
2008Q2	RR	RR	RR
2008Q3	R	RR	RR
2008Q4	RR	RR	RR
2009Q1	RR	R	R
2009Q2	R	RD	RD
2009Q3	R	RD	RR
2009Q4	RD	RD	RD
2010Q1	RD	D	RD
2010Q2	D	D	D
2010Q3	D	D	D
2010Q4	D	RD	RR
2011Q1	RR	RD	RD
2011Q2	RD	D	RD
2011Q3	D	RR	RR
2011Q4	RR	RR	RR
2012Q1	RD	RR	RD
2012Q2	RR	R	RR
2012Q3	RR	RD	RR
2012Q4	R	RD	R
2013Q1	RR	D	RR
2013Q2	R	RR	R
2013Q3	R	RR	R
2013Q4	RD	R	R
2014Q1	RD	RD	RD
2014Q2	RD	RD	RD
2014Q3	D	D	D
2014Q4	RD	D	RD
2015Q1	RD	RR	RD
2015Q2	D	R	D
2015Q3	D	RD	RR
2015Q4	RD	RD	RD
2016Q1	RR	D	RR
2016Q2	RD	D	R
2016Q3	RR	RD	RR
2016Q4	RD	RD	RD
2017Q1	RR	RD	RR
2017Q2	RD	D	R

2017Q3	RR	RR	RR
2017Q4	RR	RR	RR
2018Q1	R	RR	R
2018Q2	RD	R	RR
2018Q3	RR	R	RR
2018Q4	R	RD	R
2019Q1	RR	RD	R
2019Q2	RD	RD	RD
2019Q3	RD	D	RR
2019Q4	RD	D	RD
2020Q1	RD	RR	RD
2020Q2	RD	RD	D
2020Q3	RD	RD	D
2020Q4	RD	RD	RD

Chicago	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RR
1995Q3	RD	RD	RD
1995Q4	RD	RD	RD
1996Q1	D	D	D
1996Q2	RR	D	RR
1996Q3	RD	RR	R
1996Q4	RR	RR	RR
1997Q1	RR	RR	R
1997Q2	RD	R	RD
1997Q3	RR	R	RR
1997Q4	RD	RD	R
1998Q1	RD	D	RD
1998Q2	RR	RR	RR
1998Q3	RD	RR	R
1998Q4	RD	R	RD
1999Q1	RR	RD	RR
1999Q2	R	RD	R
1999Q3	RD	RD	RD
1999Q4	RD	RD	RD
2000Q1	D	D	D
2000Q2	RR	D	RR
2000Q3	RD	RR	R
2000Q4	RR	RR	RR
2001Q1	RR	RR	RR
2001Q2	R	R	R

2001Q3	R	R	R
2001Q4	RD	R	R
2002Q1	RR	RD	RR
2002Q2	RR	RD	RR
2002Q3	RD	D	RD
2002Q4	RR	D	RR
2003Q1	R	D	R
2003Q2	RD	RR	R
2003Q3	RR	RD	RR
2003Q4	RD	RD	RD
2004Q1	RD	RD	RD
2004Q2	RR	RD	RR
2004Q3	R	D	RR
2004Q4	RD	D	R
2005Q1	D	D	RR
2005Q2	RR	RD	RR
2005Q3	R	RD	R
2005Q4	RD	RD	R
2006Q1	RD	RD	RD
2006Q2	D	D	D
2006Q3	D	RR	RR
2006Q4	RD	RR	RD
2007Q1	RR	RR	RR
2007Q2	RR	RR	RR
2007Q3	RD	R	R
2007Q4	RR	R	RR
2008Q1	R	R	R
2008Q2	RR	RD	RR
2008Q3	R	RD	R
2008Q4	RD	RD	RD
2009Q1	RR	D	RR
2009Q2	R	D	R
2009Q3	R	D	R
2009Q4	R	RD	R
2010Q1	RD	RD	RD
2010Q2	RD	RD	RD
2010Q3	RD	RD	RD
2010Q4	D	D	D
2011Q1	RR	D	RR
2011Q2	RR	D	RR
2011Q3	RD	RR	RD
2011Q4	RD	RR	D
2012Q1	D	R	D
2012Q2	D	R	RD
2012Q3	RD	R	RD

2012Q4	D	RR	RR
2013Q1	RR	RR	RR
2013Q2	R	RR	R
2013Q3	RD	RR	RD
2013Q4	RD	RR	RD
2014Q1	D	R	RR
2014Q2	RR	RR	RR
2014Q3	RD	RR	RD
2014Q4	RD	RR	RD
2015Q1	RD	RR	RD
2015Q2	RR	R	RR
2015Q3	RD	R	R
2015Q4	RD	RD	RD
2016Q1	RR	RD	RR
2016Q2	R	RD	R
2016Q3	RD	RD	RD
2016Q4	RR	D	RR
2017Q1	R	D	R
2017Q2	RD	D	R
2017Q3	RD	RR	RR
2017Q4	RD	RR	RD
2018Q1	RD	R	RD
2018Q2	D	RD	RR
2018Q3	RD	RD	RD
2018Q4	D	D	D
2019Q1	RR	D	RR
2019Q2	R	RR	R
2019Q3	RD	RR	RD
2019Q4	RD	R	RD
2020Q1	D	R	D
2020Q2	RR	RR	RD
2020Q3	RD	RD	D
2020Q4	RD	RD	RD

Dallas	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RD
1995Q3	D	D	RR
1995Q4	RR	D	RR
1996Q1	RR	RD	R
1996Q2	RD	RD	RD
1996Q3	RD	RD	RD

1996Q4	D	D	RR
1997Q1	RD	D	RD
1997Q2	D	RR	RR
1997Q3	D	RR	RR
1997Q4	RD	RR	RR
1998Q1	RD	RR	RD
1998Q2	D	R	RR
1998Q3	RD	RD	RR
1998Q4	RR	RD	RR
1999Q1	RR	RD	RR
1999Q2	R	D	R
1999Q3	RD	D	R
1999Q4	RR	RR	RR
2000Q1	RD	RR	RD
2000Q2	RR	RD	RR
2000Q3	RR	RD	R
2000Q4	RD	RD	R
2001Q1	D	D	RR
2001Q2	RR	RR	RR
2001Q3	RR	RR	R
2001Q4	RR	RR	RR
2002Q1	RR	R	RR
2002Q2	R	R	R
2002Q3	RD	R	RD
2002Q4	RR	R	RR
2003Q1	RR	RD	RR
2003Q2	RD	RD	RD
2003Q3	RD	RD	RD
2003Q4	RD	RD	RD
2004Q1	D	RD	D
2004Q2	RD	D	RD
2004Q3	D	D	D
2004Q4	D	D	RR
2005Q1	RD	RR	RD
2005Q2	RD	R	RD
2005Q3	D	R	D
2005Q4	D	R	D
2006Q1	RD	RR	RD
2006Q2	D	RR	D
2006Q3	D	RR	D
2006Q4	RD	R	RD
2007Q1	D	R	RR
2007Q2	RR	RR	RR
2007Q3	RD	RR	RD
2007Q4	D	RR	RR

2008Q1	RD	RR	RD
2008Q2	RR	R	RR
2008Q3	RR	R	RR
2008Q4	RR	R	RR
2009Q1	RR	R	RR
2009Q2	R	R	R
2009Q3	R	RD	R
2009Q4	RD	RD	RD
2010Q1	RD	RD	RD
2010Q2	D	RD	RD
2010Q3	D	D	D
2010Q4	D	D	D
2011Q1	D	D	D
2011Q2	RR	RR	RR
2011Q3	RD	RR	R
2011Q4	RR	RR	RR
2012Q1	RD	R	R
2012Q2	D	R	RR
2012Q3	RR	R	RR
2012Q4	RR	R	RR
2013Q1	RR	RD	RR
2013Q2	RD	RD	RD
2013Q3	RR	D	RR
2013Q4	RD	D	RD
2014Q1	RD	RR	RD
2014Q2	D	RR	RR
2014Q3	RD	R	R
2014Q4	D	R	RR
2015Q1	RR	RD	RR
2015Q2	RR	RD	RR
2015Q3	RR	D	RR
2015Q4	RR	RD	R
2016Q1	RR	RD	RR
2016Q2	R	RD	R
2016Q3	R	D	R
2016Q4	R	RR	RR
2017Q1	RD	RR	RD
2017Q2	RR	RR	RR
2017Q3	R	R	R
2017Q4	RR	R	RR
2018Q1	RD	RD	R
2018Q2	RR	RD	RR
2018Q3	RD	RD	R
2018Q4	RD	D	RD
2019Q1	RR	D	RR

2019Q2	R	D	R
2019Q3	RR	D	RR
2019Q4	RD	D	RD
2020Q1	RR	RR	RR
2020Q2	RD	RD	RD
2020Q3	RD	RD	RD
2020Q4	D	RD	D

Wash DC	Error-Correction	Band-Pass	Income
1998Q1	RR	RR	RR
1998Q2	RD	RD	R
1998Q3	D	RD	RD
1998Q4	D	RD	RD
1999Q1	RR	RD	RR
1999Q2	RD	RD	R
1999Q3	RD	D	RR
1999Q4	RD	D	RD
2000Q1	RD	D	RD
2000Q2	D	RR	D
2000Q3	D	RR	RR
2000Q4	RR	RR	RR
2001Q1	RR	RR	RR
2001Q2	R	RR	R
2001Q3	R	R	RR
2001Q4	R	R	R
2002Q1	RR	R	RR
2002Q2	R	R	R
2002Q3	R	R	RR
2002Q4	R	RD	R
2003Q1	RR	RD	RR
2003Q2	RD	RD	RD
2003Q3	D	RD	RR
2003Q4	RD	RD	RD
2004Q1	RD	D	RD
2004Q2	D	D	D
2004Q3	D	D	D
2004Q4	RR	D	RR
2005Q1	RR	D	RR
2005Q2	RD	D	R
2005Q3	RR	RR	RR
2005Q4	R	RR	RR
2006Q1	RD	RR	R

2006Q2	D	RR	RR
2006Q3	RR	R	RR
2006Q4	RD	R	R
2007Q1	RD	R	RD
2007Q2	D	RD	RR
2007Q3	RD	RD	RD
2007Q4	RR	RR	RR
2008Q1	RR	RR	RR
2008Q2	R	RR	R
2008Q3	RR	RR	RR
2008Q4	RD	R	RD
2009Q1	RR	R	RR
2009Q2	R	RD	R
2009Q3	R	RD	R
2009Q4	RD	RD	RD
2010Q1	RD	RD	RD
2010Q2	D	D	RD
2010Q3	D	D	D
2010Q4	D	D	RR
2011Q1	RD	D	RD
2011Q2	RR	RR	RR
2011Q3	RR	RR	RR
2011Q4	RR	RR	RR
2012Q1	RR	RR	RR
2012Q2	R	RR	R
2012Q3	RR	RR	RR
2012Q4	RR	R	RR
2013Q1	RR	R	RR
2013Q2	RD	RD	RD
2013Q3	RR	RD	RR
2013Q4	RD	RD	RD
2014Q1	RD	D	RD
2014Q2	D	D	RD
2014Q3	D	RR	D
2014Q4	RD	RR	RD
2015Q1	RD	RR	RD
2015Q2	D	R	RR
2015Q3	RD	R	RD
2015Q4	RD	RD	RD
2016Q1	D	RD	D
2016Q2	RR	RD	RR
2016Q3	R	D	R
2016Q4	RR	RR	RR
2017Q1	RR	RR	RR

2017Q2	RD	RR	R
2017Q3	RR	RR	RR
2017Q4	RR	R	RR
2018Q1	R	R	R
2018Q2	R	RD	R
2018Q3	R	RD	RR
2018Q4	RD	RD	R
2019Q1	D	D	R
2019Q2	RR	D	RR
2019Q3	RD	D	R
2019Q4	D	RR	RR
2020Q1	RD	RR	RD
2020Q2	RR	RR	RD
2020Q3	RD	RD	D
2020Q4	RD	RD	RD

Denver	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RR	RD	RR
1995Q3	RR	D	RR
1995Q4	RR	RR	RR
1996Q1	RR	RR	RR
1996Q2	R	R	R
1996Q3	R	RD	R
1996Q4	RD	RD	R
1997Q1	RR	RD	RR
1997Q2	RD	D	R
1997Q3	RD	D	R
1997Q4	RD	D	R
1998Q1	RD	D	RD
1998Q2	D	D	RR
1998Q3	RD	RR	RR
1998Q4	D	RR	RR
1999Q1	RR	RR	RR
1999Q2	RD	RR	R
1999Q3	RD	RR	R
1999Q4	D	RR	R
2000Q1	RD	RR	RD
2000Q2	D	RR	RR
2000Q3	D	RR	RR
2000Q4	RR	R	RR
2001Q1	RR	R	RR

2001Q2	R	R	R
2001Q3	RR	RR	R
2001Q4	RR	RR	R
2002Q1	RR	R	RR
2002Q2	R	R	R
2002Q3	R	RD	R
2002Q4	R	RD	R
2003Q1	RD	RD	RD
2003Q2	D	D	D
2003Q3	RD	D	RD
2003Q4	RD	D	RD
2004Q1	RD	D	RD
2004Q2	D	D	D
2004Q3	RD	D	D
2004Q4	D	RR	D
2005Q1	D	RR	D
2005Q2	RD	RR	RD
2005Q3	RD	R	RD
2005Q4	D	R	RD
2006Q1	D	RD	RD
2006Q2	D	D	D
2006Q3	D	RR	D
2006Q4	RD	RR	D
2007Q1	RD	RR	RD
2007Q2	RR	R	RR
2007Q3	RR	R	RR
2007Q4	R	RR	RR
2008Q1	RR	RR	RR
2008Q2	R	RR	RR
2008Q3	RR	R	RR
2008Q4	R	R	RR
2009Q1	RR	R	RR
2009Q2	R	RD	R
2009Q3	R	RD	R
2009Q4	R	RD	R
2010Q1	R	RD	R
2010Q2	RR	RD	RR
2010Q3	RD	RD	RD
2010Q4	D	D	RD
2011Q1	RD	D	RD
2011Q2	RR	D	D
2011Q3	RD	RD	D
2011Q4	D	RD	D
2012Q1	D	D	RD
2012Q2	D	D	RR

2012Q3	D	RR	RR
2012Q4	RR	RR	RR
2013Q1	RR	RR	RR
2013Q2	RD	R	R
2013Q3	RD	R	R
2013Q4	D	R	R
2014Q1	RD	R	RD
2014Q2	D	RR	RR
2014Q3	D	RR	RR
2014Q4	D	R	RR
2015Q1	RD	R	RR
2015Q2	RD	RR	RR
2015Q3	D	RR	RR
2015Q4		RR	RR
2016Q1	RR	RR	RR
2016Q2	R	R	R
2016Q3	RD	R	R
2016Q4	D	RD	R
2017Q1	RD	RD	RD
2017Q2	D	D	RR
2017Q3	D	D	R
2017Q4	RD	D	R
2018Q1	RD	D	R
2018Q2	D	RD	RR
2018Q3	D	RD	RR
2018Q4	RR	RD	RR
2019Q1	RD	RD	R
2019Q2	D	RD	RR
2019Q3	RR	D	RR
2019Q4	R	D	RR
2020Q1	RR	RR	RD
2020Q2	RD	RD	D
2020Q3	RD	RD	RD
2020Q4	RD	RD	RD

Detroit	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RD
1995Q3	D	D	D
1995Q4	RR	RR	RR
1996Q1	RR	RR	R
1996Q2	RD	RR	R

1996Q3	RD	R	R
1996Q4	D	RD	RR
1997Q1	D	RD	RR
1997Q2	RD	RD	RD
1997Q3	D	D	D
1997Q4	D	RR	D
1998Q1	RD	RR	RD
1998Q2	D	R	RR
1998Q3	RR	R	RR
1998Q4	RD	RD	R
1999Q1	D	RD	RD
1999Q2	RD	D	RR
1999Q3	RR	RR	RR
1999Q4	RR	RR	R
2000Q1	RD	R	R
2000Q2	D	RD	RD
2000Q3	RR	RD	RR
2000Q4	RR	D	RR
2001Q1	RR	D	RR
2001Q2	R	D	R
2001Q3	RD	RD	R
2001Q4	RR	RD	RR
2002Q1	RR	RR	RR
2002Q2	R	RR	RD
2002Q3	RR	RR	RR
2002Q4	RR	R	RR
2003Q1	R	R	R
2003Q2	RD	RD	RD
2003Q3	RD	RD	D
2003Q4	D	RD	D
2004Q1	D	D	D
2004Q2	RR	D	RR
2004Q3	RD	RD	RD
2004Q4	RD	RD	D
2005Q1	RR	D	RR
2005Q2	RD	D	RD
2005Q3	RR	RR	RR
2005Q4	RR	RR	RR
2006Q1	R	R	R
2006Q2	RD	R	RD
2006Q3	RD	R	RD
2006Q4	RR	RR	RR
2007Q1	R	RR	R
2007Q2	R	RR	R
2007Q3	RD	R	RD

2007Q4	D	RD	RD
2008Q1	RD	RD	D
2008Q2	RR	D	RR
2008Q3	R	D	RD
2008Q4	RR	RR	RR
2009Q1	RR	RR	RR
2009Q2	R	R	R
2009Q3	R	RD	RD
2009Q4	RD	RD	RD
2010Q1	RD	D	RD
2010Q2	D	D	D
2010Q3	D	RR	D
2010Q4	D	RR	D
2011Q1	RD	R	RD
2011Q2	RR	RD	RR
2011Q3	RD	RR	R
2011Q4	RR	RR	RR
2012Q1	RD	RR	RD
2012Q2	D	R	RR
2012Q3	RR	R	RR
2012Q4	RR	RD	R
2013Q1	RR	RD	RR
2013Q2	RD	D	R
2013Q3	RD	RR	RR
2013Q4	RR	RR	RR
2014Q1	RD	RD	RD
2014Q2	RD	RD	RD
2014Q3	RD	RD	RD
2014Q4	RD	D	RD
2015Q1	RD	D	RD
2015Q2	D	RR	D
2015Q3	RR	RR	RR
2015Q4	RD	R	R
2016Q1	RR	RD	RR
2016Q2	R	RD	R
2016Q3	RR	D	RR
2016Q4	R	RR	R
2017Q1	RR	RR	RR
2017Q2	RR	RD	RR
2017Q3	R	RD	R
2017Q4	RD	RR	R
2018Q1	RR	RR	RR
2018Q2	R	RR	R
2018Q3	RD	R	RR
2018Q4	RR	RD	RR

2019Q1	RR	RD	R
2019Q2	RD	D	RD
2019Q3	RR	RR	RR
2019Q4	RD	RR	RR
2020Q1	RD	RD	RD
2020Q2	D	D	RD
2020Q3	D	RD	D
2020Q4	D	RD	D

Honolulu	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RR	RD	RR
1995Q3	RR	D	RR
1995Q4	RR	RR	RR
1996Q1	RR	RR	RR
1996Q2	R	R	R
1996Q3	RR	R	RD
1996Q4	R	R	RD
1997Q1	RD	RD	RD
1997Q2	RR	D	D
1997Q3	RD	RR	RD
1997Q4	RD	RR	RD
1998Q1	D	RR	D
1998Q2	RD	RR	RD
1998Q3	RD	RR	RD
1998Q4	D	RR	RD
1999Q1	RD	RR	D
1999Q2	RD	R	RD
1999Q3	RR	R	RD
1999Q4	RD	RD	RD
2000Q1	RD	RD	RD
2000Q2	RR	D	D
2000Q3	RD	RR	D
2000Q4	D	RR	D
2001Q1	RD	RR	RR
2001Q2	D	RR	RD
2001Q3	RD	R	D
2001Q4	D	R	D
2002Q1	RD	R	RD
2002Q2	D	R	RR
2002Q3	RD	R	RR
2002Q4	D	RD	RR

2003Q1	RD	RD	RR
2003Q2	RD	RD	R
2003Q3	RD	RD	R
2003Q4	RD	D	R
2004Q1	RD	D	RD
2004Q2	D	RD	RR
2004Q3	RD	RD	RR
2004Q4	D	RD	RR
2005Q1	RD	D	RD
2005Q2	D	D	RR
2005Q3	RD	RR	RR
2005Q4	D	RR	RR
2006Q1	RR	RR	RR
2006Q2	R	R	R
2006Q3	R	R	R
2006Q4	RR	R	R
2007Q1	R	R	RR
2007Q2	RR	R	R
2007Q3	R	RD	R
2007Q4	RR	RD	R
2008Q1	R	RD	R
2008Q2	RR	RD	RR
2008Q3	R	D	RR
2008Q4	R	D	RR
2009Q1	R	RR	RR
2009Q2	RR	RD	R
2009Q3	R	RD	R
2009Q4	R	RD	R
2010Q1	RD	RD	RD
2010Q2	RR	D	RR
2010Q3	RR	D	RR
2010Q4	RR	RR	RR
2011Q1	RR	RR	RR
2011Q2	R	R	R
2011Q3	RR	R	R
2011Q4	RR	R	R
2012Q1	R	RR	R
2012Q2	RR	R	RR
2012Q3	R	R	RR
2012Q4	R	RD	RR
2013Q1	RR	RD	RR
2013Q2	RD	D	R
2013Q3	RD	D	R
2013Q4	RD	RR	RD
2014Q1	RD	RR	RD

2014Q2	D	R	D
2014Q3	D	R	D
2014Q4	RD	R	D
2015Q1	D	RR	RD
2015Q2	D	RR	D
2015Q3	RD	R	RR
2015Q4	D	RD	RR
2016Q1	RD	RD	RR
2016Q2	RR	D	R
2016Q3	RD	RR	RR
2016Q4	RR	RR	RR
2017Q1	RR	RR	RR
2017Q2	RD	R	R
2017Q3	D	RD	R
2017Q4	RD	RD	R
2018Q1	D	RD	RD
2018Q2	RD	D	RR
2018Q3	RR	D	R
2018Q4	RR	D	R
2019Q1	RD	D	RR
2019Q2	RR	D	R
2019Q3	RD	D	R
2019Q4	D	RR	R
2020Q1	RD	RR	RD
2020Q2	RD	RR	RD
2020Q3	RR	R	RD
2020Q4	RD	R	RD

Houston	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RR	RD
1995Q3	RR	R	RR
1995Q4	RD	R	RD
1996Q1	RD	R	RD
1996Q2	D	RR	D
1996Q3	RD	RR	D
1996Q4	RD	R	RD
1997Q1	RD	R	RD
1997Q2	D	RD	D
1997Q3	D	RD	RD
1997Q4	RD	RR	RD
1998Q1	RD	RR	RD

1998Q2	D	RR	RR
1998Q3	D	R	RR
1998Q4	RD	R	RD
1999Q1	RR	RD	RR
1999Q2	RD	RD	R
1999Q3	D	RD	R
1999Q4	D	D	RR
2000Q1	RD	RD	RD
2000Q2	D	RD	RR
2000Q3	RR	RD	RR
2000Q4	R	D	R
2001Q1	RD	D	R
2001Q2	RR	RR	RR
2001Q3	R	RR	RR
2001Q4	R	R	R
2002Q1	RR	R	RR
2002Q2	RR	R	RR
2002Q3	RR	RR	RR
2002Q4	R	RR	R
2003Q1	R	R	R
2003Q2	RR	R	RR
2003Q3	R	RD	R
2003Q4	RR	RD	R
2004Q1	RR	RD	RR
2004Q2	RD	D	RD
2004Q3	RD	D	D
2004Q4	D	D	D
2005Q1	D	RD	D
2005Q2	RD	RD	RD
2005Q3	RD	RD	RD
2005Q4	D	D	D
2006Q1	RD	RR	RD
2006Q2	D	RR	RR
2006Q3	RD	RR	RD
2006Q4	D	R	D
2007Q1	RR	RD	RR
2007Q2	RD	RD	RD
2007Q3	RD	D	RD
2007Q4	D	D	D
2008Q1	RD	RR	RD
2008Q2	RR	RR	RR
2008Q3	RR	RR	RR
2008Q4	RR	R	RR
2009Q1	RR	R	RR
2009Q2	R	RD	R

2009Q3	RR	RD	RR
2009Q4	R	D	R
2010Q1	RD	D	RD
2010Q2	D	RD	D
2010Q3	RD	RD	RD
2010Q4	D	RD	D
2011Q1	RD	RD	RD
2011Q2	RD	D	D
2011Q3	D	D	D
2011Q4	D	RR	D
2012Q1	RR	RR	RR
2012Q2	RD	RR	RR
2012Q3	RD	R	RD
2012Q4	RR	R	RR
2013Q1	RR	R	RR
2013Q2	R	R	R
2013Q3	RD	RD	R
2013Q4	D	RD	RR
2014Q1	RD	RD	RD
2014Q2	RR	D	RR
2014Q3	RD	RR	R
2014Q4	RR	RR	RR
2015Q1	RD	RR	R
2015Q2	RR	RR	RR
2015Q3	RR	R	RR
2015Q4	R	R	R
2016Q1	RR	R	RR
2016Q2	R	R	R
2016Q3	R	RD	R
2016Q4	RR	RD	RR
2017Q1	RD	RD	RD
2017Q2	D	D	D
2017Q3	D	D	D
2017Q4	D	D	D
2018Q1	RD	D	RD
2018Q2	D	RD	RR
2018Q3	D	RD	R
2018Q4	RD	RD	RD
2019Q1	D	D	D
2019Q2	RR	RR	RR
2019Q3	RD	RR	R
2019Q4	RD	RR	RD
2020Q1	D	RR	D
2020Q2	RD	RD	RD
2020Q3	D	RD	RD

2020Q4	D	RD	RR
LA	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RD
1995Q3	D	RD	RD
1995Q4	D	RD	D
1996Q1	D	D	D
1996Q2	D	D	D
1996Q3	D	D	RR
1996Q4	RD	D	RD
1997Q1	RR	D	RR
1997Q2	RD	D	RD
1997Q3	D	D	RR
1997Q4	RD	D	RD
1998Q1	RD	RR	RD
1998Q2	D	RR	D
1998Q3	D	RR	RR
1998Q4	D	RR	RR
1999Q1	RR	R	RR
1999Q2	RD	R	R
1999Q3	RD	R	RR
1999Q4	RD	RD	RD
2000Q1	RD	RD	RD
2000Q2	D	D	RR
2000Q3	RR	RR	RR
2000Q4	RR	RR	RR
2001Q1	RR	RR	RR
2001Q2	R	RR	R
2001Q3	R	R	R
2001Q4	R	R	R
2002Q1	RR	R	RR
2002Q2	R	RD	R
2002Q3	R	RD	R
2002Q4	RR	RD	RR
2003Q1	RR	RD	RR
2003Q2	RD	D	R
2003Q3	RD	D	RD
2003Q4	D	D	RR
2004Q1	D	RR	RR
2004Q2	D	RR	RR
2004Q3	RD	R	RR
2004Q4	D	R	R
2005Q1	D	RD	RR
2005Q2	RD	RD	R

2005Q3	RD	RD	R
2005Q4	D	D	R
2006Q1	RD	D	RD
2006Q2	D	RR	RR
2006Q3	RD	RR	R
2006Q4	RR	RR	RR
2007Q1	RR	RR	RR
2007Q2	R	RR	R
2007Q3	R	RR	R
2007Q4	RR	RR	RR
2008Q1	RR	RR	RR
2008Q2	R	R	R
2008Q3	RR	R	RR
2008Q4	R	R	R
2009Q1	RR	RD	RR
2009Q2	R	RD	R
2009Q3	R	RD	R
2009Q4	RD	RD	RD
2010Q1	RD	D	RD
2010Q2	D	D	D
2010Q3	RD	D	RD
2010Q4	D	RR	D
2011Q1	D	RR	D
2011Q2	RD	RR	RD
2011Q3	RD	R	RD
2011Q4	D	R	D
2012Q1	RD	RR	RD
2012Q2	D	RR	RR
2012Q3	RR	RR	RR
2012Q4	RR	RR	RR
2013Q1	RR	R	RR
2013Q2	R	R	R
2013Q3	RD	R	R
2013Q4	RD	RD	R
2014Q1	RD	RD	RD
2014Q2	D	D	D
2014Q3	D	D	RR
2014Q4	D	RR	RD
2015Q1	RD	RR	RD
2015Q2	D	RD	RR
2015Q3	D	RD	RR
2015Q4	D	RD	RR
2016Q1	RR	D	RR
2016Q2	R	D	R
2016Q3	RR	RR	RR

2016Q4	R	RR	R
2017Q1	R	R	R
2017Q2	RD	RD	R
2017Q3	RD	RD	RR
2017Q4	RR	RD	RR
2018Q1	RR	D	R
2018Q2	RR	D	RR
2018Q3	RR	RR	RR
2018Q4	RR	RR	RR
2019Q1	RR	RR	RR
2019Q2	RD	R	R
2019Q3	RD	R	R
2019Q4	RD	R	R
2020Q1	RD	RD	RD
2020Q2	RR	RD	RD
2020Q3	RD	D	D
2020Q4	RD	RD	RD

Miami	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RR
1995Q3	RD	D	RD
1995Q4	D	RR	RR
1996Q1	RR	RR	RR
1996Q2	R	R	R
1996Q3	RD	RD	R
1996Q4	RR	RD	RR
1997Q1	RR	RD	RR
1997Q2	RD	D	R
1997Q3	RD	D	RD
1997Q4	D	RR	D
1998Q1	RD	RR	RD
1998Q2	D	RD	D
1998Q3	D	RD	D
1998Q4	D	RD	RR
1999Q1	RR	D	RR
1999Q2	RD	D	RD
1999Q3	D	RD	D
1999Q4	D	D	D
2000Q1	RD	D	RD
2000Q2	D	RR	RR
2000Q3	RD	RR	RR

2000Q4	D	RR	R
2001Q1	RR	R	RR
2001Q2	R	R	R
2001Q3	R	RR	RR
2001Q4	RR	RR	R
2002Q1	RR	RR	RR
2002Q2	R	R	R
2002Q3	R	R	RR
2002Q4	RR	RD	R
2003Q1	RR	RD	RR
2003Q2	RD	RD	R
2003Q3	RD	D	RD
2003Q4	D	D	RR
2004Q1	D	D	R
2004Q2	RD	RR	R
2004Q3	RD	RD	R
2004Q4	D	RD	RR
2005Q1	RR	RD	RR
2005Q2	RD	RD	R
2005Q3	D	RD	RR
2005Q4	D	D	R
2006Q1	D	D	RR
2006Q2	RR	RR	RR
2006Q3	RD	RR	RR
2006Q4	RR	RR	RR
2007Q1	RR	R	RR
2007Q2	R	R	R
2007Q3	RR	R	R
2007Q4	RR	RR	RR
2008Q1	RR	RR	R
2008Q2	RR	RR	RR
2008Q3	R	R	R
2008Q4	R	RD	RR
2009Q1	RR	RD	RR
2009Q2	R	RD	RD
2009Q3	RR	D	RR
2009Q4	RD	D	RD
2010Q1	RD	RR	RD
2010Q2	D	RR	D
2010Q3	RD	R	RD
2010Q4	D	RD	RR
2011Q1	RR	RD	RD
2011Q2	R	D	RR
2011Q3	RD	RR	RD
2011Q4	D	RR	RR

2012Q1	RD	RR	RD
2012Q2	RR	R	RR
2012Q3	RR	R	RR
2012Q4	RR	RD	RR
2013Q1	RR	RD	RR
2013Q2	R	RD	R
2013Q3	RD	D	R
2013Q4	D	D	RR
2014Q1	RD	RR	R
2014Q2	D	RR	RD
2014Q3	RD	RR	RD
2014Q4	D	R	RR
2015Q1	RD	R	R
2015Q2	RD	RD	RD
2015Q3	RR	RD	RR
2015Q4	RR	D	R
2016Q1	RR	D	RR
2016Q2	R	RR	R
2016Q3	RR	RR	RR
2016Q4	R	R	R
2017Q1	RD	RD	R
2017Q2	RD	RD	R
2017Q3	RD	RD	RD
2017Q4	D	RD	RR
2018Q1	RR	D	RR
2018Q2	R	D	RR
2018Q3	RD	RR	RD
2018Q4	D	RR	RR
2019Q1	RR	R	RR
2019Q2	RD	R	R
2019Q3	RD	RD	RD
2019Q4	RD	RD	RD
2020Q1	RD	RR	D
2020Q2	D	RD	D
2020Q3	D	RD	RR
2020Q4	RD	RD	RD

Minneapolis	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RR	RR
1995Q3	D	RR	RR
1995Q4	D	R	RR

1996Q1	RD	R	RD
1996Q2	D	R	RR
1996Q3	RD	R	R
1996Q4	D	R	RR
1997Q1	RR	R	RR
1997Q2	RD	RD	RD
1997Q3	RD	RD	RD
1997Q4	RD	RD	RD
1998Q1	RD	RD	RD
1998Q2	D	RD	D
1998Q3	D	D	RR
1998Q4	D	D	RR
1999Q1	RR	D	RR
1999Q2	R	D	R
1999Q3	RR	D	RR
1999Q4	R	RR	R
2000Q1	RD	RR	RD
2000Q2	RR	RR	RR
2000Q3	RR	R	RR
2000Q4	RR	R	RR
2001Q1	RR	R	RR
2001Q2	R	RR	R
2001Q3	R	RR	R
2001Q4	R	RR	R
2002Q1	RR	R	RR
2002Q2	R	R	R
2002Q3	RD	R	R
2002Q4	D	RD	R
2003Q1	RD	RD	RD
2003Q2	D	D	D
2003Q3	RD	D	RD
2003Q4	D	RR	D
2004Q1	RD	RR	RD
2004Q2	D	R	D
2004Q3	RD	RD	RD
2004Q4	D	RD	D
2005Q1	RR	RD	RR
2005Q2	RD	D	RD
2005Q3	RD	D	RD
2005Q4	RD	D	RD
2006Q1	RD	D	RD
2006Q2	D	D	D
2006Q3	D	D	D
2006Q4	D	RR	D
2007Q1	RR	RR	RR

2007Q2	RD	RR	R
2007Q3	RD	R	RD
2007Q4	RR	R	RR
2008Q1	RR	R	RR
2008Q2	RR	RR	RR
2008Q3	R	RR	R
2008Q4	R	RR	R
2009Q1	RR	R	RR
2009Q2	R	R	R
2009Q3	RR	RD	RR
2009Q4	R	RD	R
2010Q1	RD	RD	RD
2010Q2	D	D	D
2010Q3	RD	D	RD
2010Q4	D	D	D
2011Q1	RD	D	RD
2011Q2	D	D	D
2011Q3	D	RR	RR
2011Q4	RD	RR	RR
2012Q1	RD	RR	RD
2012Q2	D	R	RR
2012Q3	RD	R	R
2012Q4	RR	RD	RR
2013Q1	RR	RD	RR
2013Q2	R	D	R
2013Q3	RD	RR	RD
2013Q4	D	RR	RR
2014Q1	RD	RR	R
2014Q2	D	R	R
2014Q3	RD	R	RD
2014Q4	RD	RD	RD
2015Q1	RD	RD	RD
2015Q2	D	D	D
2015Q3	RR	D	RR
2015Q4	R	D	R
2016Q1	RR	RD	RR
2016Q2	R	RD	R
2016Q3	RR	D	RR
2016Q4	R	D	R
2017Q1	R	RR	R
2017Q2	RR	RR	R
2017Q3	RD	R	R
2017Q4	RR	RD	RR
2018Q1	RD	RD	R
2018Q2	RR	D	RR

2018Q3	R	D	R
2018Q4	RR	RR	RR
2019Q1	RR	RR	RR
2019Q2	R	RR	R
2019Q3	RR	R	RR
2019Q4	RD	RD	R
2020Q1	RD	RD	RD
2020Q2	D	D	RR
2020Q3	D	RD	RR
2020Q4	D	RD	RR

New York	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RR
1995Q3	RD	RD	RD
1995Q4	D	D	RR
1996Q1	RR	D	RR
1996Q2	RD	RR	R
1996Q3	RD	RR	R
1996Q4	D	R	RR
1997Q1	D	R	RR
1997Q2	RD	RD	R
1997Q3	RD	RD	RR
1997Q4	D	D	RR
1998Q1	RD	D	RD
1998Q2	D	RD	D
1998Q3	D	RD	RR
1998Q4	D	RD	RR
1999Q1	RD	RD	RD
1999Q2	RD	D	RD
1999Q3	D	D	D
1999Q4	D	RR	RR
2000Q1	RD	RR	RD
2000Q2	D	RR	D
2000Q3	RR	R	RR
2000Q4	RD	R	R
2001Q1	RR	RD	RR
2001Q2	R	RD	R
2001Q3	RD	D	R
2001Q4	RR	RR	RR
2002Q1	RR	RR	RR
2002Q2	R	R	R

2002Q3	R	R	R
2002Q4	RR	RD	RR
2003Q1	RR	RD	R
2003Q2	R	D	R
2003Q3	R	D	R
2003Q4	RD	D	R
2004Q1	RD	RD	R
2004Q2	RR	RD	RR
2004Q3	RD	RD	R
2004Q4	RR	D	R
2005Q1	RR	RR	RR
2005Q2	RD	RR	R
2005Q3	RD	RR	RR
2005Q4	RD	R	R
2006Q1	RD	R	R
2006Q2	D	RR	RR
2006Q3	RD	R	R
2006Q4	RD	RD	RD
2007Q1	RD	RD	RD
2007Q2	D	RD	RR
2007Q3	RR	D	RR
2007Q4	RR	RR	RR
2008Q1	RR	RR	RR
2008Q2	RR	RR	R
2008Q3	RR	RR	RR
2008Q4	R	R	R
2009Q1	RR	R	RR
2009Q2	R	RD	R
2009Q3	RR	RD	RR
2009Q4	R	D	R
2010Q1	RD	D	RD
2010Q2	D	D	RR
2010Q3	RD	RR	RR
2010Q4	D	R	RD
2011Q1	D	RD	D
2011Q2	RR	RD	RR
2011Q3	R	RD	R
2011Q4	RD	D	RD
2012Q1	RD	RR	RD
2012Q2	RR	RR	RR
2012Q3	RR	RR	RR
2012Q4	RR	R	R
2013Q1	RR	R	RR
2013Q2	R	R	R
2013Q3	RD	RR	R

2013Q4	D	RR	RR
2014Q1	RD	R	RD
2014Q2	D	RD	RR
2014Q3	RD	RD	RD
2014Q4	D	D	D
2015Q1	RD	RR	RD
2015Q2	D	RR	D
2015Q3	D	RR	RR
2015Q4	RD	R	R
2016Q1	RR	R	RR
2016Q2	RD	RD	RD
2016Q3	D	RD	D
2016Q4	RD	D	D
2017Q1	RD	D	RD
2017Q2	D	RD	D
2017Q3	RD	RD	RD
2017Q4	D	RD	D
2018Q1	RR	RD	RR
2018Q2	RD	D	RD
2018Q3	RD	D	D
2018Q4	D	RR	RR
2019Q1	D	RR	RR
2019Q2	RD	R	R
2019Q3	RD	R	RD
2019Q4	RD	RD	RD
2020Q1	D	RR	D
2020Q2	RD	RD	RD
2020Q3	RD	RD	RD
2020Q4	RD	RD	RD

Philadelphia	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RR	RD
1995Q3	D	R	RR
1995Q4	D	RD	R
1996Q1	RD	RD	RD
1996Q2	D	RR	D
1996Q3	RR	RR	RR
1996Q4	RD	RR	RD
1997Q1	D	R	RR
1997Q2	RD	R	R
1997Q3	RD	RD	RD
1997Q4	RD	RD	RD
1998Q1	RD	D	RD

1998Q2	D	RR	D
1998Q3	RR	RR	RR
1998Q4	RD	R	R
1999Q1	RR	RD	RR
1999Q2	RD	RD	RD
1999Q3	RD	D	RD
1999Q4	RD	D	RD
2000Q1	D	RR	RR
2000Q2	RD	RR	RD
2000Q3	D	RD	RD
2000Q4	D	RD	RR
2001Q1	RR	D	RR
2001Q2	RR	RR	RR
2001Q3	RD	RR	R
2001Q4	RD	R	R
2002Q1	RR	RD	RR
2002Q2	RD	RD	R
2002Q3	RR	RD	RR
2002Q4	R	D	R
2003Q1	RD	RR	R
2003Q2	D	RR	R
2003Q3	RR	RR	RR
2003Q4	R	R	R
2004Q1	RD	RD	RD
2004Q2	D	RD	RR
2004Q3	RR	D	RR
2004Q4	RR	D	RR
2005Q1	R	D	R
2005Q2	RD	RD	RD
2005Q3	D	RD	RR
2005Q4	RR	RD	RR
2006Q1	RR	D	R
2006Q2	R	RR	R
2006Q3	RD	RR	R
2006Q4	RD	RR	R
2007Q1	RD	R	RD
2007Q2	RR	R	RR
2007Q3	RR	R	R
2007Q4	RR	R	RR
2008Q1	R	R	R
2008Q2	RR	R	RR
2008Q3	RR	R	RR
2008Q4	R	RD	R
2009Q1	R	RD	R
2009Q2	RR	RD	R

2009Q3	RR	RD	RR
2009Q4	R	RD	R
2010Q1	RD	RD	RD
2010Q2	D	RD	D
2010Q3	RD	D	RD
2010Q4	D	D	D
2011Q1	RR	D	RR
2011Q2	RD	RR	RD
2011Q3	RR	RR	RR
2011Q4	R	RR	R
2012Q1	RD	R	RD
2012Q2	RR	R	RR
2012Q3	RR	R	RR
2012Q4	R	R	R
2013Q1	RR	RR	RR
2013Q2	RD	RR	RD
2013Q3	RR	R	RR
2013Q4	RR	RD	RR
2014Q1	RD	D	RD
2014Q2	D	RR	D
2014Q3	D	RR	D
2014Q4	RD	RR	RR
2015Q1	RD	R	RD
2015Q2	D	R	RD
2015Q3	D	RD	D
2015Q4	RD	RD	RD
2016Q1	D	D	D
2016Q2	D	D	RR
2016Q3	D	D	RD
2016Q4	RR	RR	RR
2017Q1	R	RR	RR
2017Q2	RD	RD	R
2017Q3	RD	RD	RD
2017Q4	D	D	RD
2018Q1	RD	RR	RD
2018Q2	D	RR	RR
2018Q3	RD	R	RD
2018Q4	D	RD	RR
2019Q1	RR	RD	RR
2019Q2	RD	D	R
2019Q3	RR	RR	RR
2019Q4	RD	RR	RD
2020Q1	RD	R	RD
2020Q2	RD	RD	RD
2020Q3	D	RD	D

2020Q4	RD	RD	RD

Phoenix	Error-Correction	Band-Pass	Income
2002Q1	RR	RR	RR
2002Q2	R	R	R
2002Q3	R	RD	R
2002Q4	RD	RD	R
2003Q1	RD	RD	RD
2003Q2	RD	RD	RD
2003Q3	RD	RD	RD
2003Q4	RD	D	RD
2004Q1	RD	RD	RD
2004Q2	D	RD	D
2004Q3	D	RD	D
2004Q4	D	RD	D
2005Q1	RD	D	RD
2005Q2	D	D	D
2005Q3	D	D	D
2005Q4	D	RR	D
2006Q1	RD	RR	RD
2006Q2	D	RR	RR
2006Q3	RR	RR	RR
2006Q4	RR	RR	RR
2007Q1	RR	RR	RR
2007Q2	R	RR	R
2007Q3	RR	R	RR
2007Q4	RR	R	RR
2008Q1	RR	R	RR
2008Q2	R	R	R
2008Q3	R	R	R
2008Q4	R	RD	R
2009Q1	RR	RD	RR
2009Q2	R	RD	R
2009Q3	R	RD	RD
2009Q4	RD	RD	RD
2010Q1	RD	RD	RD
2010Q2	D	D	D
2010Q3	D	D	D
2010Q4	D	D	D
2011Q1	RD	D	D
2011Q2	D	RR	D
2011Q3	D	RR	RR
2011Q4	RR	RR	RR
2012Q1	RR	RR	RR

2012Q2	R	RR	R
2012Q3	RR	R	RR
2012Q4	RR	R	RR
2013Q1	RR	R	RR
2013Q2	R	R	R
2013Q3	R	RR	R
2013Q4	RD	RR	R
2014Q1	RD	R	R
2014Q2	D	R	R
2014Q3	RD	RD	R
2014Q4	RD	RD	R
2015Q1	RD	RD	RD
2015Q2	D	D	RR
2015Q3	D	D	RR
2015Q4	RR	D	RR
2016Q1	RR	D	RR
2016Q2	R	RD	R
2016Q3	R	RD	R
2016Q4	R	RD	R
2017Q1	RD	D	R
2017Q2	RR	D	RR
2017Q3	RR	RR	RR
2017Q4	RR	RR	RR
2018Q1	RR	RR	RR
2018Q2	R	RR	R
2018Q3	RR	RR	RR
2018Q4	RR	RR	RR
2019Q1	RR	RR	RR
2019Q2	R	RR	R
2019Q3	R	R	R
2019Q4	RD	R	R
2020Q1	RD	RD	R
2020Q2	RD	D	R
2020Q3	RD	RD	RD
2020Q4	RD	RD	RD

San Diego	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RR	RD
1995Q3	RD	R	D
1995Q4	D	R	D
1996Q1	D	RD	D

1996Q2	RR	RD	RD
1996Q3	RD	RD	D
1996Q4	RD	RD	D
1997Q1	D	RD	D
1997Q2	RD	D	D
1997Q3	RD	D	D
1997Q4	D	RR	D
1998Q1	RD	RR	RD
1998Q2	D	RR	RR
1998Q3	D	RR	RR
1998Q4	D	R	RR
1999Q1	RR	R	RR
1999Q2	RD	R	R
1999Q3	RD	RD	R
1999Q4	D	RD	R
2000Q1	RD	RD	RD
2000Q2	RR	D	RR
2000Q3	RR	D	RR
2000Q4	RR	RR	RR
2001Q1	RR	RR	RR
2001Q2	R	RR	R
2001Q3	R	R	RR
2001Q4	RR	R	RR
2002Q1	RR	R	RR
2002Q2	R	RR	R
2002Q3	R	RR	R
2002Q4	RR	R	R
2003Q1	R	R	R
2003Q2	RR	RD	R
2003Q3	RD	RD	R
2003Q4	RD	D	R
2004Q1	D	D	R
2004Q2	RD	RD	RR
2004Q3	RD	RD	R
2004Q4	D	RD	R
2005Q1	D	RD	RR
2005Q2	RD	D	R
2005Q3	RD	D	R
2005Q4	RD	D	R
2006Q1	RD	RR	RD
2006Q2	D	RD	RR
2006Q3	RR	RD	RR
2006Q4	RR	D	RR
2007Q1	R	RR	R
2007Q2	RR	RR	RR

2007Q3	RR	RR	RR
2007Q4	RR	RR	RR
2008Q1	RR	RR	RR
2008Q2	R	R	R
2008Q3	R	R	R
2008Q4	R	R	R
2009Q1	RR	R	RR
2009Q2	R	RD	R
2009Q3	R	RD	R
2009Q4	RD	RD	RD
2010Q1	RD	RD	RD
2010Q2	D	D	D
2010Q3	RD	D	D
2010Q4	D	D	D
2011Q1	RR	D	D
2011Q2	R	D	RD
2011Q3	RD	RR	D
2011Q4	D	RR	D
2012Q1	RD	RR	RD
2012Q2	D	R	D
2012Q3	RD	R	RR
2012Q4	D	R	RR
2013Q1	RR	R	RR
2013Q2	RD	R	R
2013Q3	RD	RD	RD
2013Q4	D	RD	RD
2014Q1	RD	RD	RD
2014Q2	D	D	D
2014Q3	D	D	D
2014Q4	D	RR	D
2015Q1	RD	RR	RD
2015Q2	D	R	D
2015Q3	D	R	RR
2015Q4	D	RD	RR
2016Q1	D	RD	RR
2016Q2	RD	D	RR
2016Q3	D	RR	RR
2016Q4	RR	RR	RR
2017Q1	RR	RR	RR
2017Q2	RD	RR	R
2017Q3	D	R	R
2017Q4	RR	RR	R
2018Q1	RR	R	RR
2018Q2	RD	R	R
2018Q3	RR	RD	R

2018Q4	RR	RD	R
2019Q1	RR	RD	RR
2019Q2	RD	RD	R
2019Q3	RD	D	RD
2019Q4	RD	D	RD
2020Q1	RD	RR	RD
2020Q2	RD	RD	RD
2020Q3	RD	RD	RD
2020Q4	RD	RD	RD

Seattle	Error-Correction	Band-Pass	Income
1998Q1	RR	RD	R
1998Q2	RD	D	RR
1998Q3	D	RR	RR
1998Q4	RR	RR	R
1999Q1	R	RD	RR
1999Q2	RD	RD	R
1999Q3	RD	RD	RD
1999Q4	RR	D	RR
2000Q1	RD	D	RD
2000Q2	RR	RR	RR
2000Q3	RR	RR	RR
2000Q4	RR	RR	RR
2001Q1	R	RR	RR
2001Q2	RR	RR	R
2001Q3	RR	R	RR
2001Q4	RR	R	R
2002Q1	RD	R	R
2002Q2	RD	RD	RD
2002Q3	D	RD	RR
2002Q4	RD	RD	RD
2003Q1	RD	RD	RD
2003Q2	D	D	RD
2003Q3	RD	D	RD
2003Q4	RD	RD	D
2004Q1	D	RD	RD
2004Q2	RD	RD	D
2004Q3	RD	D	D
2004Q4	D	D	D
2005Q1	RD	D	RR
2005Q2	RD	D	R
2005Q3	D	D	RR

2005Q4	D	RR	R
2006Q1	RD	RR	RD
2006Q2	D	RR	RR
2006Q3	D	RR	R
2006Q4	RR	RR	RR
2007Q1	RR	RR	R
2007Q2	RR	RR	RR
2007Q3	RR	RR	RR
2007Q4	RR	RR	RR
2008Q1	RR	R	R
2008Q2	RR	R	RR
2008Q3	RR	R	RR
2008Q4	R	R	R
2009Q1	R	RD	RR
2009Q2	RR	RD	R
2009Q3	R	RD	RD
2009Q4	R	RD	RD
2010Q1	RD	RD	RD
2010Q2	D	D	D
2010Q3	RD	D	D
2010Q4	RR	D	D
2011Q1	RR	D	RD
2011Q2	R	RR	RD
2011Q3	RR	RR	RR
2011Q4	RR	RR	RR
2012Q1	R	R	RD
2012Q2	R	R	RR
2012Q3	RD	R	RR
2012Q4	RR	R	RR
2013Q1	RR	R	RR
2013Q2	RD	RR	R
2013Q3	D	RR	RR
2013Q4	RR	R	R
2014Q1	R	R	RD
2014Q2	RD	R	RR
2014Q3	RR	RD	RR
2014Q4	RR	RD	RR
2015Q1	R	RD	R
2015Q2	RD	D	RR
2015Q3	D	D	RR
2015Q4	RR	D	RR
2016Q1	R	RD	RR
2016Q2	RD	RD	R
2016Q3	RR	D	RR
2016Q4	RR	D	R

2017Q1	RD	RR	R
2017Q2	RD	RR	RR
2017Q3	RR	RR	RR
2017Q4	RR	R	R
2018Q1	RD	R	R
2018Q2	RD	RD	RR
2018Q3	RR	RD	R
2018Q4	RR	RD	R
2019Q1	RD	D	R
2019Q2	RD	D	RD
2019Q3	RR	RR	RR
2019Q4	R	RR	R
2020Q1	R	RR	RR
2020Q2	R	R	R
2020Q3	RD	RD	RD
2020Q4	RD	RD	RD

San Fran	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RD
1995Q3	RD	RD	RD
1995Q4	D	D	D
1996Q1	RD	D	RD
1996Q2	D	D	RR
1996Q3	RR	D	RR
1996Q4	R	D	R
1997Q1	RR	RR	RR
1997Q2	RD	RR	R
1997Q3	RR	RR	RR
1997Q4	RD	R	R
1998Q1	RD	R	RD
1998Q2	D	RD	RR
1998Q3	RD	RD	R
1998Q4	RR	D	R
1999Q1	RR	D	RR
1999Q2	RD	RD	R
1999Q3	RD	RD	R
1999Q4	RD	RD	R
2000Q1	RD	D	RD
2000Q2	D	D	RR
2000Q3	RR	RR	RR
2000Q4	RR	RR	RR

2001Q1	RR	RR	RR
2001Q2	R	R	R
2001Q3	R	R	R
2001Q4	RR	R	R
2002Q1	R	RD	R
2002Q2	RD	RD	RD
2002Q3	RD	D	RR
2002Q4	D	D	RR
2003Q1	RR	D	R
2003Q2	RD	RD	RD
2003Q3	RD	RD	RD
2003Q4	D	D	D
2004Q1	D	D	RD
2004Q2	RD	D	D
2004Q3	RD	D	D
2004Q4	D	RD	D
2005Q1	D	RD	D
2005Q2	RD	RD	RD
2005Q3	D	D	RD
2005Q4	D	D	D
2006Q1	RD	RR	D
2006Q2	D	RR	D
2006Q3	RD	RR	D
2006Q4	RR	RR	RR
2007Q1	RR	RR	RR
2007Q2	R	R	R
2007Q3	R	R	RR
2007Q4	RR	R	RR
2008Q1	RR	R	R
2008Q2	RR	RR	RR
2008Q3	R	RR	RR
2008Q4	R	R	R
2009Q1	RR	R	RR
2009Q2	R	RD	R
2009Q3	R	RD	R
2009Q4	RD	RD	RD
2010Q1	RD	D	RD
2010Q2	D	D	D
2010Q3	RD	D	D
2010Q4	D	D	D
2011Q1	D	RR	D
2011Q2	RR	RR	RR
2011Q3	RD	RR	R
2011Q4	D	RR	R
2012Q1	RD	RR	RD

2012Q2	D	RR	RR
2012Q3	RR	R	RR
2012Q4	RR	R	R
2013Q1	RR	R	RR
2013Q2	RD	R	R
2013Q3	RD	RR	R
2013Q4	D	RR	RR
2014Q1	RD	RR	R
2014Q2	RD	RR	RR
2014Q3	D	R	RR
2014Q4	D	R	R
2015Q1	RD	R	RD
2015Q2	D	R	RR
2015Q3	D	RR	RR
2015Q4	RR	RR	RR
2016Q1	RR	RR	R
2016Q2	RR	R	RR
2016Q3	R	R	R
2016Q4	RR	RD	RR
2017Q1	R	RD	R
2017Q2	RD	RD	R
2017Q3	RD	D	RD
2017Q4	RR	RR	RR
2018Q1	R	RR	R
2018Q2	RD	R	R
2018Q3	D	RD	R
2018Q4	RR	RD	RR
2019Q1	RR	RD	RR
2019Q2	RD	D	RD
2019Q3	D	D	D
2019Q4	D	RR	RR
2020Q1	RD	RR	RD
2020Q2	RD	RD	RD
2020Q3	D	RD	D
2020Q4	RD	RD	RD

St. Louis	EC	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RR	RR
1995Q3	D	R	RR
1995Q4	RD	R	R
1996Q1	RD	RD	RD
1996Q2	D	RD	RR

1996Q3	RR	D	RR
1996Q4	RD	RR	RD
1997Q1	RD	RR	RD
1997Q2	D	RR	RR
1997Q3	RR	RR	RR
1997Q4	RD	R	RD
1998Q1	RD	R	RD
1998Q2	D	RD	D
1998Q3	RR	RD	RR
1998Q4	RD	RD	RD
1999Q1	RR	RD	RD
1999Q2	RD	D	D
1999Q3	RR	D	RR
1999Q4	RD	D	R
2000Q1	RD	RR	RD
2000Q2	D	RR	RR
2000Q3	RD	RR	RD
2000Q4	RR	RR	RR
2001Q1	RR	RR	RR
2001Q2	R	RR	R
2001Q3	RD	R	RD
2001Q4	RR	R	RR
2002Q1	RR	R	RR
2002Q2	R	RD	R
2002Q3	RR	RD	R
2002Q4	R	RD	R
2003Q1	R	D	R
2003Q2	RR	RR	RR
2003Q3	R	RR	R
2003Q4	RR	RR	RR
2004Q1	R	R	RR
2004Q2	R	R	R
2004Q3	RD	RD	R
2004Q4	RR	RD	RR
2005Q1	RR	RD	RR
2005Q2	R	RD	R
2005Q3	RD	D	R
2005Q4	RD	D	RD
2006Q1	RD	RR	RD
2006Q2	D	RR	D
2006Q3	D	RR	RD
2006Q4	D	RR	D
2007Q1	RR	RR	RR
2007Q2	RD	R	R
2007Q3	RD	R	RR

2007Q4	D	R	R
2008Q1	RD	R	RD
2008Q2	D	RD	RR
2008Q3	RR	RD	RR
2008Q4	RR	RD	RR
2009Q1	RR	RD	RR
2009Q2	R	RD	R
2009Q3	RR	D	R
2009Q4	R	D	RR
2010Q1	R	D	RR
2010Q2	RR	D	R
2010Q3	R	D	R
2010Q4	RR	RR	RR
2011Q1	R	RR	RR
2011Q2	RD	RR	R
2011Q3	RD	RR	RD
2011Q4	D	R	RR
2012Q1	RD	R	R
2012Q2	RR	R	RR
2012Q3	R	R	R
2012Q4	RR	RD	R
2013Q1	RR	RD	RR
2013Q2	R	RD	R
2013Q3	R	RD	RR
2013Q4	R	RD	R
2014Q1	RD	RD	RD
2014Q2	D	RD	RD
2014Q3	RD	RD	RD
2014Q4	D	D	D
2015Q1	RD	D	RD
2015Q2	D	RR	RR
2015Q3	RR	RR	RR
2015Q4	RD	RR	R
2016Q1	RD	R	RD
2016Q2	D	R	RR
2016Q3	RR	RD	RR
2016Q4	R	RD	R
2017Q1	RR	RD	RR
2017Q2	R	D	R
2017Q3	RD	D	R
2017Q4	RD	RR	R
2018Q1	RD	RR	RR
2018Q2	RR	RR	RR
2018Q3	RD	R	RD
2018Q4	D	R	RR

2019Q1	RR	RD	RR
2019Q2	RD	RD	RD
2019Q3	D	D	RR
2019Q4	D	RR	RR
2020Q1	RD	RR	RD
2020Q2	RR	RD	RD
2020Q3	RD	D	D
2020Q4	RD	RD	RD

Tampa	Error-Correction	Band-Pass	Income
1995Q1	D	D	D
1995Q2	RD	RD	RD
1995Q3	D	RD	RR
1995Q4	D	D	RR
1996Q1	RD	D	RD
1996Q2	RR	RD	RR
1996Q3	RD	RD	RR
1996Q4	D	RD	RR
1997Q1	RR	D	RR
1997Q2	R	D	R
1997Q3	RD	RR	R
1997Q4	RD	RR	R
1998Q1	RD	R	R
1998Q2	D	R	RR
1998Q3	RD	RD	RR
1998Q4	D	RD	RR
1999Q1	RR	RD	RR
1999Q2	RD	RD	R
1999Q3	RD	D	R
1999Q4	RD	RR	R
2000Q1	RD	RR	RD
2000Q2	D	RR	RR
2000Q3	D	R	RR
2000Q4	RR	R	RR
2001Q1	RR	RR	RR
2001Q2	RR	RR	RR
2001Q3	RR	RR	RR
2001Q4	RR	RR	RR
2002Q1	RR	R	RR
2002Q2	R	R	R
2002Q3	R	RD	R
2002Q4	R	RD	R

2003Q1	RD	RD	RD
2003Q2	D	RD	RR
2003Q3	RD	D	RD
2003Q4	RD	D	RD
2004Q1	RD	D	RD
2004Q2	D	RD	D
2004Q3	RD	RD	D
2004Q4	D	D	RR
2005Q1	RD	D	RD
2005Q2	D	D	RR
2005Q3	D	RR	RR
2005Q4	D	RR	RR
2006Q1	D	RR	R
2006Q2	RR	RR	RR
2006Q3	RR	RR	RR
2006Q4	RR	RR	RR
2007Q1	RR	RR	RR
2007Q2	R	R	R
2007Q3	RR	R	R
2007Q4	R	R	R
2008Q1	R	R	R
2008Q2	RR	RD	RR
2008Q3	RR	RD	R
2008Q4	R	RD	RR
2009Q1	RR	RD	RR
2009Q2	R	RD	R
2009Q3	R	RD	RD
2009Q4	RD	D	RD
2010Q1	RD	D	RD
2010Q2	D	D	D
2010Q3	RD	D	D
2010Q4	D	D	D
2011Q1	RD	D	RD
2011Q2	D	D	D
2011Q3	RD	RR	D
2011Q4	D	RR	RR
2012Q1	RR	RR	RR
2012Q2	RR	R	RR
2012Q3	R	R	RR
2012Q4	RR	R	RR
2013Q1	RR	R	RR
2013Q2	R	RR	R
2013Q3	R	RR	R
2013Q4	R	RR	R
2014Q1	RD	R	R

2014Q2	D	R	RR
2014Q3	RR	R	RR
2014Q4	RR	R	RR
2015Q1	R	R	R
2015Q2	RR	RD	RR
2015Q3	RR	RD	RR
2015Q4	RR	RD	RR
2016Q1	RR	RD	RR
2016Q2	R	D	R
2016Q3	RR	D	RR
2016Q4	R	RR	RR
2017Q1	RR	RR	RR
2017Q2	R	R	R
2017Q3	RR	RD	R
2017Q4	R	RD	R
2018Q1	RD	RD	RD
2018Q2	RR	D	RR
2018Q3	RR	D	RR
2018Q4	RR	RR	RR
2019Q1	RR	RR	RR
2019Q2	R	R	R
2019Q3	R	R	R
2019Q4	R	R	R
2020Q1	R	RD	R
2020Q2	RD	D	R
2020Q3	RD	RD	R
2020Q4	RD	RD	R

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