Morgan Blein

Forecasting housing prices in San Francisco

Objective: building an objective forecasting model for the San Francisco SP-Case-Shiller home prices index using publicly available data (see part III for more details about these variables).

Tools: STATA/ excel

Stata do file: a script file containing all the information to run the desired analysis in Stata.

Here is a link to the Do file for this project.

Here is a link to the data compiled for this project.

Method: Regression

OUTLINE:

I) Introduction

Standard and Poor's is rating agency, mostly famed by the stock trading index S&P 500. However, stock markets is not the only thing they monitor. Starting in the 1970s, they developed a housing prices index, for major metropolitan areas. Today, they generate these indexes for the 20 largest cities in the United States. Today, we are going to focus on the San Francisco home prices index. This index starts in January of 1980.

Here are facts about our data:

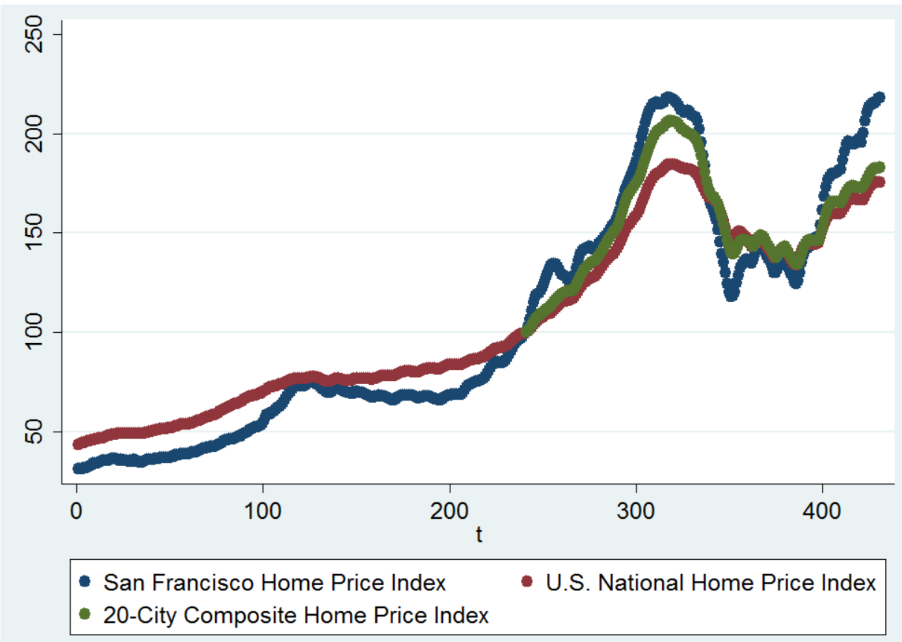
- Number of observation: 431.
- Each observation corresponds to a value for a given month.
- Time period range: from January 1980, until November 2015.
- Index Jan 2000=100

The main area of focus of this study will be first seasonality. Do any seasonal pattern exist? Do they have an impact on the home index values? Then, we will choose several external variables in order to run a causal regression on the SF home price index. In other words, what are the driving forces behind the value of this index? In order to do so, we are going to carefully choose variables and discuss their consistency and unbiaisness. The final step of our analysis will consist of a forecasting model, in order to generate potential values for February 2016 and October 2016.

II) Seasonality:

A section of seasonality that includes a regression table, any F-statistic calculation, and a written narrative description of the seasonality patterns

1) Plot home price index/ t (period unit in month)



We can see from the graph that the values of all 3 indexes (San Francisco home index, U.S National home index, 20-city composite home index) all follow the same trend. There are obvious variations, but as a whole, the curves tend to behave in the same way.

Over time, the indexes for home prices grows. This intuitively makes sense: it is common knowledge that a house today is worth a lot more than in the 1980. I suspect the value of t (time unit in month over the whole period) to be heavily correlated to the San Francisco home price index (and other indexes). The relationship seems pretty linear in nature (or maybe exponential, more calculation will be done in the next section) especially up to period T equals to about 300. After, this we can notice a severe decrease in the price index. That period corresponds to May 2007 or the US housing bubble burst. This trend drove prices down until March 2012, when index values start rising again.

1) <u>Linear seasonality trend:</u>

yt = α0 + α1t + et , t = 1, 2, etc..

We can infer from the graph the influence of time over the price indexes. However, we still do not know if any other seasonality during the year from month to month occurs. I order to confirm those assumption and get answer, we regress the variable **SanFranciscoHomePriceIndex** on a linear time trend and 11 monthly dummy variables, using January as the base month.

```
. regress SanFranciscoHomePriceIndex t Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
```

Source	SS	df	MS
Model	1139863.59	12	94988.6324
Residual	295990.703	418	708.11173
Total	1435854.29	430	3339.19603

Number of obs	=	431
F(12, 418)	=	134.14
Prob > F	=	0.0000
R-squared	=	0.7939
Adj R-squared	=	0.7879
Root MSE	=	26.61

SanFrancis~x	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	.413051	.0103052	40.08	0.000	.3927946	.4333075
Feb	-.3766621	6.272133	-0.06	0.952	-12.70551	11.95219
Mar	.1447313	6.272158	0.02	0.982	-12.18417	12.47363
Apr	1.229458	6.2722	0.20	0.845	-11.09953	13.55844
May	2.268074	6.27226	0.36	0.718	-10.06103	14.59717
Jun	2.883912	6.272336	0.46	0.646	-9.445339	15.21316
Jul	3.147805	6.272429	0.50	0.616	-9.181629	15.47724
Aug	2.947254	6.272539	0.47	0.639	-9.382396	15.2769
Sep	2.665314	6.272666	0.42	0.671	-9.664586	14.99521
Oct	2.211985	6.27281	0.35	0.725	-10.1182	14.54217
Nov	1.634212	6.272971	0.26	0.795	-10.69629	13.96471
Dec	.216356	6.316976	0.03	0.973	-12.20064	12.63335
_cons	13.53262	4.939409	2.74	0.006	3.823446	23.2418

- Number of observations: 431
- Adjusted R-squared: 0.79
- Prob > F = 0.0000. The model is statically significant: null hypothesis is rejected.

The regression equation sums up to:

- SanFranciscoHomePriceIndex = 13.53 + .413 t – 0.376 feb - .1447 mar + 1.22 apr + 2.26 may + 2.88 jun + 3.14 jul + 2.95 aug + 2.66 sep + 2.21 oct + 1.63 nov + 0.21 dec

It feel when looking at the coefficients that months would have a great influence on the San Francisco home index price. However, I think these variables are not statistically significant. Their P values are very much over 5% ranging from 0.616 to 0.982). Their "t" values are very low and the standard error much too high.
T however has a P-value of 0. We can assume the high R squared comes from this time over period's trend (since all other variables are non-significant)
Key findings: seasonality over t exists, however no seasonal trend for months seem to exist.

2) <u>Exponential trend</u>

$\log(yt) = \alpha 0 + \alpha 1 t + et$,$t = 1, 2$

To decide whether to follow a linear or exponential trend model, we need to create a log variable based on SanFranciscoHomePriceIndex. We call this variable SanFranciscoHomePriceIndex_log and it follows this equation:

SanFranciscoHomePriceIndex_log = log(SanFranciscoHomePriceIndex)

We now run a regression trend model based on this new variable:

```
. regress SanFranciscoHomePriceIndex_log t Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

      Source |       SS       df       MS              Number of obs =     431
-------------+------------------------------           F( 12,   418) =  266.40
       Model |  132.498837    12  11.0415697           Prob > F      =  0.0000
    Residual |  17.3248223   418  .041446943           R-squared     =  0.8844
-------------+------------------------------           Adj R-squared =  0.8810
       Total |  149.823659   430  .348427114           Root MSE      =  .20359

------------------------------------------------------------------------------
SanFrancis~g |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |   .0044543   .0000788    56.50   0.000     .0042993    .0046092
         Feb |   -.003265   .0479856    -0.07   0.946    -.0975881    .0910581
         Mar |  -.0000613   .0479858    -0.00   0.999    -.0943848    .0942621
         Apr |   .0082015   .0479861     0.17   0.864    -.0861226    .1025256
         May |   .0173105   .0479865     0.36   0.718    -.0770145    .1116355
         Jun |   .0230017   .0479871     0.48   0.632    -.0713244    .1173278
         Jul |   .0258816   .0479878     0.54   0.590     -.068446    .1202091
         Aug |   .0246674   .0479887     0.51   0.608    -.0696618    .1189966
         Sep |    .022332   .0479896     0.47   0.642    -.0719991    .1166631
         Oct |   .0180217   .0479907     0.38   0.707    -.0763116     .112355
         Nov |   .0125977    .047992     0.26   0.793     -.081738    .1069334
         Dec |   .0079835   .0483286     0.17   0.869     -.087014     .102981
       _cons |   3.507485   .0377894    92.82   0.000     3.433204    3.581766
------------------------------------------------------------------------------
```

- Number of observations: 431
- Adjusted R-squared: 0.88
- Prob > F = 0.0000. The model is statically significant: null hypothesis is rejected.

The R squared went up from 79% to 88%. All variables other than t seem statically irrelevant, same as before. However this seems to give a better base for the analysis.

This will have to be kept in mind when doing the causal analysis. There are 2 approaches I took to deal with this time trend:

Method 1:

- Keep the t variable in the regression model, use the variables SanFranciscoHomePriceIndex or SanFranciscoHomePriceIndex_log to run the regression

Method 2:

- Use STATA tools to detrend SanFranciscoHomePriceIndex or SanFranciscoHomePriceIndex_log. New variables named SFHomePriceIndex _detrended and SFHomePriceIndex_log_detrended will be created. Alos use stata to detrend the independent variables.

We can make sure these variables are de-trended by running a new regression on one of them:

```
. regress SFHomePriceIndex_detrended t

      Source |       SS       df       MS              Number of obs =     431
-------------+------------------------------           F(  1,   429) =    0.00
       Model |  5.8208e-11     1  5.8208e-11           Prob > F      =  1.0000
    Residual |  296652.806   429  691.498382           R-squared     =  0.0000
-------------+------------------------------           Adj R-squared = -0.0023
       Total |  296652.806   430  689.890246           Root MSE      =  26.296

------------------------------------------------------------------------------
x_detrended |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |  -4.67e-11   .0101806    -0.00   1.000     -.02001      .02001
       _cons |   2.62e-08   2.537717     0.00   1.000    -4.987905    4.987905
------------------------------------------------------------------------------
```

The model has no statistical significance. Time therefore has no influence on the new variable anymore.

III) <u>explanatory variables</u>

In this section, I will list the explanatory variables I included, their sources, as well as providing a justification for their use.

1) <u>30 years Mortgage rates</u>

30-Year Fixed Rate Mortgage Average in the United States© (MORTGAGE30US)

Download Data

Source(s):	Freddie Mac
Release:	Primary Mortgage Market Survey
Units:	Percent Description of growth rate formulas
Frequency:	Monthly Aggregation Method: Average
Date Range:	1971-04-02 to 2016-01-21
File Format:	Excel
Seasonal Adjustment:	Not Seasonally Adjusted
Notes:	Data is provided "as is," by Freddie Mac® with no warranties of any kind, express or implied, including, but not limited to, warranties of accuracy or implied warranties of merchantability or fitness for a particular purpose. Use of the data is at the user's sole risk. In no event will Freddie Mac be liable for any damages arising out of or related to the data, including, but not limited to direct, indirect, incidental, special, consequential, or punitive damages, whether under a contract, tort, or any other theory of liability, even if Freddie Mac is aware of the possibility of such damages. Copyright, 2014, Freddie Mac. Reprinted with permission.
Updated:	2016-01-21 10:54 AM CST

Download Data

Freddie Mac, *30-Year Fixed Rate Mortgage Average in the United States*© [MORTGAGE30US], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/MORTGAGE30US, January 26, 2016.

Mortgage rates could have an impact on house prices index, as they are directly to take into account. Most people resort to mortgages when buying a house. The 30 year mortgage is the most popular. Moreover the data given covers the whole period I am interested in. As seen in the screen shot above, the data is sourced monthly (using the average aggregation method) and covers our whole time period range (January 1980 to November 2015)

The data is not seasonally adjusted. When regressing with t (time unit) we get:

```
. regress MORTGAGE30US t

      Source |       SS       df       MS              Number of obs =     431
-------------+------------------------------           F(  1,   429) = 2681.31
       Model |  4289.8952     1   4289.8952            Prob > F      =  0.0000
    Residual |  686.368727   429   1.5999271           R-squared     =  0.8621
-------------+------------------------------           Adj R-squared =  0.8617
       Total |  4976.26393   430  11.5727068           Root MSE      =  1.2649

------------------------------------------------------------------------------
MORTGAGE30US |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |  -.0253571   .0004897   -51.78   0.000    -.0263196   -.0243946
       _cons |   13.70885   .1220668   112.31   0.000     13.46892    13.94877
------------------------------------------------------------------------------
```

The R squared is 86%. We need to detrend this variable.

2) <u>15 years Mortgage rates:</u>

15-Year Fixed Rate Mortgage Average in the United States© (MORTGAGE15US)

Download Data

Source(s):	Freddie Mac
Release:	Primary Mortgage Market Survey
Units:	Percent Description of growth rate formulas
Frequency:	Monthly Aggregation Method: Average
Date Range:	1991-08-30 to 2016-01-21
File Format:	Excel
Seasonal Adjustment:	Not Seasonally Adjusted
Notes:	Data is provided "as is," with no warranties of any kind, express or implied, including, but not limited to, warranties of accuracy or implied warranties of merchantability or fitness for a particular purpose. Use of the data is at the user's sole risk. In no event will Freddie Mac be liable for any damages arising out of or related to the data, including, but not limited to direct, indirect, incidental, special, consequential, or punitive damages, whether under a contract, tort, or any other theory of liability, even if Freddie Mac is aware of the possibility of such damages. Copyright, 2014, Freddie Mac. Reprinted with permission.
Updated:	2016-01-21 10:56 AM CST

Download Data

Freddie Mac, *15-Year Fixed Rate Mortgage Average in the United States*© [MORTGAGE15US], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/MORTGAGE15US, January 25, 2016.

Same explanation as for the 30 year mortgage. I thought it was worth including as some people may choose this option instead of the 30 year mortgage.

The data is not seasonally adjusted. When regressing with t (time unit) we get:

```
. regress MORTGAGE15US t

      Source |       SS       df       MS              Number of obs =     291
-------------+------------------------------           F(  1,   289) = 1532.13
       Model |  672.091006     1  672.091006           Prob > F      =  0.0000
    Residual |  126.773958   289  .438664215           R-squared     =  0.8413
-------------+------------------------------           Adj R-squared =  0.8408
       Total |  798.864964   290  2.75470677           Root MSE      =  .66232

------------------------------------------------------------------------------
MORTGAGE15US |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |  -.0180912   .0004622   -39.14   0.000    -.0190009   -.0171815
       _cons |   10.91732   .1377701    79.24   0.000     10.64616    11.18848
------------------------------------------------------------------------------
```

The R squared is 84%. Therefore we need to create a detrended series of values for this variable.

3) Unemployment rates:

Civilian Unemployment Rate (UNRATE)

Download Data

Source(s):	US. Bureau of Labor Statistics
Release:	Employment Situation
Units:	Percent Description of growth rate formulas
Frequency:	Monthly
Date Range:	1948-01-01 to 2015-12-01
File Format:	Excel
Seasonal Adjustment:	Seasonally Adjusted
Notes:	The unemployment rate represents the number of unemployed as a percentage of the labor force. Labor force data are restricted to people 16 years of age and older, who currently reside in 1 of the 50 states or the District of Columbia, who do not reside in institutions (e.g., penal and mental facilities, homes for the aged), and who are not on active duty in the Armed Forces. This rate is also defined as the U-3 measure of labor underutilization. The series comes from the 'Current Population Survey (Household Survey)' The source code is: LNS14000000
Updated:	2016-01-08 8:11 AM CST

Download Data

US. Bureau of Labor Statistics, *Civilian Unemployment Rate* [UNRATE], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/UNRATE, January 27, 2016.

This is needed as it can also have an impact on home prices. It is a reflation on the general economic wellbeing of a state or area. As mentioned in Moody's case-shiller-methodology:"The unemployment rate is relevant since the buyers of lower-cost homes tend to be lower income and are thus more sensitive to the local business cycle and job prospects than higher-income households."

The data is already seasonally adjusted. We do not need to detrend this variable further.

4) Consumer price index:

Consumer Price Index for All Urban Consumers: All Items (CPIAUCNS)

Download Data

Source(s):	US. Bureau of Labor Statistics
Release:	Consumer Price Index
Units:	Index 1982-1984=100 Description of growth rate formulas
Frequency:	Monthly
Date Range:	1913-01-01 to 2015-12-01
File Format:	Excel
Seasonal Adjustment:	Not Seasonally Adjusted
Notes:	Handbook of Methods - (http://www.bls.gov/opub/hom/pdf/homch17.pdf) Understanding the CPI: Frequently Asked Questions - (http://stats.bls.gov:80/cpi/cpifaq.htm)
Updated:	2016-01-20 9:21 AM CST

Download Data

US. Bureau of Labor Statistics, *Consumer Price Index for All Urban Consumers: All Items* [CPIAUCSL], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/CPIAUCSL, January 27, 2016.

The Consumer Price Index (CPI) is a defined as: “measure of the average change over time in the prices of consumer items—goods and services that people buy for day-to-day living.” (http://www.bls.gov/opub/hom/pdf/homch17.pdf)

It gives a good estimate of how daily products varies in price over time. It will be interesting to compare against as purchase such as a home.

The data is not seasonally adjusted. When regressing with t (time unit) we get:

```
. regress CPIAUCNS t

      Source |       SS       df       MS              Number of obs =     431
-------------+------------------------------           F(  1,   429) =       .
       Model |  919753.767     1  919753.767           Prob > F      =  0.0000
    Residual |  2310.21822   429  5.38512406           R-squared     =  0.9975
-------------+------------------------------           Adj R-squared =  0.9975
       Total |  922063.985   430  2144.33485           Root MSE      =  2.3206

------------------------------------------------------------------------------
    CPIAUCNS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |   .3712887   .0008984   413.27   0.000     .3695228    .3730545
       _cons |   82.43261   .2239471   368.09   0.000     81.99244    82.87278
------------------------------------------------------------------------------
```

The R squared is 99%. Therefore we will also create a detrended version of this variable.

5) <u>SP500 stock index:</u>

https://finance.yahoo.com/q/hp?s=%5EGSPC&a=00&b=3&c=1950&d=00&e=26&f=2016&g=m

Note: the opening price was the index selected.

According to: http://us.spindices.com/, The S&P 500 is: “widely regarded as the best single gauge of large-cap U.S. equities[…] The index includes 500 leading companies and captures approximately 80% coverage of available market capitalization.” This indicator covers a very wide range to address stock trading overall health and trends. In the United States, it can severely impact the overall economic standing of the nation. Trying to find a correlation with home prices will tell us more about the relationship between the 2 indexes.

The data is not seasonally adjusted. When regressing with t (time unit) we get:

```
. regress SP500 t

      Source |       SS       df       MS              Number of obs =     431
-------------+------------------------------           F(  1,   429) = 2718.30
       Model |   112567941     1   112567941           Prob > F      =  0.0000
    Residual |  17765385.1   429  41411.1541           R-squared     =  0.8637
-------------+------------------------------           Adj R-squared =  0.8634
       Total |   130333326   430  303100.759           Root MSE      =   203.5

------------------------------------------------------------------------------
       SP500 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |   4.107554   .0787834    52.14   0.000     3.952704    4.262403
       _cons |  -64.82661    19.6384    -3.30   0.001    -103.4261   -26.22715
------------------------------------------------------------------------------
```

The R squared is 86%. Therefore we will also create a detrended version of this variable.

6) <u>Treasury Average Yield:</u>

Treasury Inflation-Indexed Long-Term Average Yield (DLTIIT)

Download Data

Source(s):	Board of Governors of the Federal Reserve System (US)
Release:	H.15 Selected Interest Rates
Units:	Percent Description of growth rate formulas
Frequency:	Monthly Aggregation Method: Average
Date Range:	2003-01-02 to 2016-01-20
File Format:	Excel
Seasonal Adjustment:	Not Seasonally Adjusted

Board of Governors of the Federal Reserve System (US), *Treasury Inflation-Indexed Long-Term Average Yield* [DLTIIT], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/DLTIIT, January 27, 2016.

Treasury yield is the interest rate the U.S. government pays to borrow money for different lengths of time. It is considered one of the safest investment due to the stability of the US government. Usually, their yield is very low. The influence of their rates however extends to more than just the US government: "they also influence the interest rates individuals and businesses pay to borrow money to buy real estate, vehicles and equipment." (http://www.investopedia.com/terms/t/treasury-yield.asp)

The data is not seasonally adjusted. When regressing with t (time unit) we get:

```
. regress DLTIIT t

      Source |       SS       df       MS              Number of obs =     155
-------------+------------------------------           F(  1,   153) =  277.40
       Model |  65.0078442     1  65.0078442           Prob > F      =  0.0000
    Residual |  35.8552435   153  .234347997           R-squared     =  0.6445
-------------+------------------------------           Adj R-squared =  0.6422
       Total |  100.863088   154  .654955115           Root MSE      =   .4841

------------------------------------------------------------------------------
      DLTIIT |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |  -.0144739    .000869   -16.66   0.000    -.0161907    -.012757
       _cons |   6.752335   .3100828    21.78   0.000     6.139738    7.364931
------------------------------------------------------------------------------
```

The R squared is 64%. This is still high enough to justify detrending the values of this series.

7) Consumer opinion confidence indicators

Consumer Opinion Surveys: Confidence Indicators: Composite Indicators: OECD Indicator for the United States© (CSCICP03USM665S)

Download Data

Source(s):	Organization for Economic Co-operation and Development
Release:	Main Economic Indicators (Not a Press Release)
Units:	Normalised (Normal=100) Description of growth rate formulas
Frequency:	Monthly
Date Range:	1960-01-01 to 2015-03-01
File Format:	Excel
Seasonal Adjustment:	Seasonally Adjusted
Notes:	OECD descriptor ID: CSCICP03 OECD unit ID: IXNSA OECD country ID: USA All OECD data should be cited as follows: OECD, "Main Economic Indicators - complete database", Main Economic Indicators (database),http://dx.doi.org/10.1787/data-00052-en (Accessed on date) Copyright, 2014, OECD. Reprinted with permission.
Updated:	2015-06-08 2:13 PM CDT

Organization for Economic Co-operation and Development, *Consumer Opinion Surveys: Confidence Indicators: Composite Indicators: OECD Indicator for the United States©* [CSCICP03USM665S], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/CSCICP03USM665S, January 27, 2016.

This index is very interesting. It is a behavioral index, relying on the psychology of purchase. It shows to confidence level of consumers to make a purchase in the United States. The format is monthly as usual, and the data ranges from the 1960s to early 2015.

The data is seasonally adjusted. When regressing with t (time unit) we get:

```
. regress CSCICP03USM665S t

      Source |       SS       df       MS              Number of obs =     423
-------------+------------------------------           F(  1,   421) =    4.28
       Model |  9.39253789     1  9.39253789           Prob > F      =  0.0392
    Residual |  923.927326   421  2.19460173           R-squared     =  0.0101
-------------+------------------------------           Adj R-squared =  0.0077
       Total |  933.319864   422  2.21165845           Root MSE      =  1.4814

------------------------------------------------------------------------------
CSCICP0~665S |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           t |  -.0012203   .0005899    -2.07   0.039    -.0023798   -.0000609
       _cons |    100.229   .1443139   694.52   0.000     99.94535    100.5127
------------------------------------------------------------------------------
```

The R squared is around 1%. Therefore, no need to create a detrended value. We can see the website did a good job detrending time out of this variable.

8) SP-Case-Shiller home prices indexes:

S&P created home price indexes for the 20 largest metropolitan areas in the United States. We collected data for each of these cities (Atlanta, Boston, Chicago, Cleveland, Dallas, Denver, Detroit, Las Vegas, Los Angeles, Miami, Minneapolis, New York phoenix Portland, San Diego, san Francisco, Seattle, Tampa, Washington DC). We also collected the National US average home price index, as well as a composite index for all top 20 cities.

http://us.spindices.com/indices/real-estate/sp-case-shiller-ca-san-francisco-home-price-index

This concludes our variables selection section. In short:

- 22 variables for home price indexes
- 7 external econometric variables

IV) Causal regressions:

1) First set of regressions

Section describing your causal regressions, describing its results in both a table and written narrative, and discussing its consistency and unbiasedness

We will run for sets of regression. All explanatory variables (described in the previous section) are the same for these regression, except for the time period (t) that will be added as an explanatory variable for the non-de-trended Y-variables (see end of section II) Seasonality)

Method 1:

a) Using Y= SanFranciscoHomePriceIndex, t included, X variables as they are.
b) Using Y= SanFranciscoHomePriceIndex_log, t included, X variables as they are.

Method 2:

c) Using Y= SFHomePriceIndex_detrended, X variables detrended
d) Using Y= SFHomePriceIndex_log_detrended, X variables detrended

a) Using Y= SanFranciscoHomePriceIndex, t included

```
. regress SanFranciscoHomePriceIndex t CPIAUCNS CSCICP03USM665S MORTGAGE15US MORTGAGE30US SP500 DLTIIT Unemp

      Source |       SS       df       MS              Number of obs =     147
-------------+------------------------------           F(  8,   138) =  126.90
       Model |  128896.839     8  16112.1049           Prob > F      =  0.0000
    Residual |  17522.0952   138  126.971705           R-squared     =  0.8803
-------------+------------------------------           Adj R-squared =  0.8734
       Total |  146418.934   146  1002.86941           Root MSE      =  11.268

------------------------------------------------------------------------------
SanFranciscoH~x |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------+-------------------------------------------------------------
              t |   1.231491   .3259778     3.78   0.000     .5869344    1.876049
       CPIAUCNS |   -2.33618   .7819566    -2.99   0.003    -3.882346   -.7900148
CSCICP03USM665S |    6.97218   2.097486     3.32   0.001     2.824813    11.11955
   MORTGAGE15US |    35.4995   8.489016     4.18   0.000     18.71414    52.28486
   MORTGAGE30US |   -1.72116    11.7231    -0.15   0.883    -24.90129    21.45897
          SP500 |   .0288105   .0162533     1.77   0.079    -.0033273    .0609483
         DLTIIT |  -20.87479   4.765712    -4.38   0.000    -30.29805   -11.45153
          Unemp |   -4.41948    1.77325    -2.49   0.014    -7.925732   -.9132268
          _cons |  -584.6029   264.6347    -2.21   0.029    -1107.866   -61.33985
------------------------------------------------------------------------------
```

- Adjusted R-squared: 0.88
- Prob > F = 0.0000. The model is statically significant: null hypothesis is rejected.

b) Using Y= SanFranciscoHomePriceIndex_log, t included

```
. regress SanFranciscoHomePriceIndex_log t CPIAUCNS CSCICP03USM665S MORTGAGE15US MORTGAGE30US SP500 DLTIIT Unemp

      Source |       SS       df       MS              Number of obs =     147
-------------+------------------------------           F(  8,   138) =  135.16
       Model |  4.6264368      8   .5783046            Prob > F      =  0.0000
    Residual | .590461955    138  .00427871            R-squared     =  0.8868
-------------+------------------------------           Adj R-squared =  0.8803
       Total | 5.21689875    146  .035732183           Root MSE      =  .06541

------------------------------------------------------------------------------
SanFranciscoH~g |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
----------------+-------------------------------------------------------------
              t |   .0065244   .0018923     3.45   0.001     .0027827     .010266
       CPIAUCNS |   -.013186   .0045393    -2.90   0.004    -.0221615   -.0042105
CSCICP03USM665S |   .0379934   .0121759     3.12   0.002     .0139179    .0620689
   MORTGAGE15US |   .1707353   .0492788     3.46   0.001     .0732961    .2681745
   MORTGAGE30US |   .0203534   .0680527     0.30   0.765    -.1142075    .1549143
          SP500 |   .0002213   .0000944     2.35   0.020     .0000347    .0004079
         DLTIIT |  -.1198626    .027665    -4.33   0.000    -.1745647   -.0651605
          Unemp |  -.0251029   .0102937    -2.44   0.016    -.0454567   -.0047491
          _cons |   1.049918   1.536207     0.68   0.495     -1.98763    4.087465
------------------------------------------------------------------------------
```

- Adjusted R-squared: 0.88
- Prob > F = 0.0000. The model is statically significant: null hypothesis is rejected.

c) Using Y= SFHomePriceIndex_detrended

```
. regress SFHomePriceIndex_detrended CPIAUCNS_detrended CSCICP03USM665S  MORTGAGE30US_detrended  MORTGAGE15US_detrended SP500_detr
> ended Unemp DLTIIT_detrended

      Source |       SS       df       MS              Number of obs =     147
-------------+------------------------------           F(  7,   139) =  224.35
       Model |  205865.502     7  29409.3574           Prob > F      =  0.0000
    Residual |   18220.934   139  131.085856           R-squared     =  0.9187
-------------+------------------------------           Adj R-squared =  0.9146
       Total |  224086.436   146   1534.8386           Root MSE      =  11.449

------------------------------------------------------------------------------
SFHomePriceIndex_det~d |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    CPIAUCNS_detrended |   -1.73482   .7506227    -2.31   0.022    -3.218934   -.2507051
       CSCICP03USM665S |   8.144688   2.069813     3.93   0.000     4.052301    12.23708
MORTGAGE30US_detrended |  -24.95997   6.370618    -3.92   0.000    -37.55582   -12.36413
MORTGAGE15US_detrended |    50.3977   5.724034     8.80   0.000     39.08026    61.71513
      SP500_detrended |   .0308778   .0164903     1.87   0.063    -.0017264     .063482
                 Unemp |   -5.01018   1.783494    -2.81   0.006    -8.536464   -1.483896
      DLTIIT_detrended |  -15.50108   4.246333    -3.65   0.000    -23.89684   -7.105329
                 _cons |  -755.2191   205.1821    -3.68   0.000    -1160.901   -349.5377
------------------------------------------------------------------------------
```

- Adjusted R-squared: 0.918
- Prob > F = 0.0000. The model is statically significant: null hypothesis is rejected.

d) Using Y= SFHomePriceIndex_log_detrended

```
. regress SFHomePriceIndex_log_detrended CPIAUCNS_detrended CSCICP03USM665S  MORTGAGE30US_detrended  MORTGAGE15US_detrended SP500_
> detrended Unemp DLTIIT_detrended

      Source |       SS       df       MS              Number of obs =     147
-------------+------------------------------           F(  7,   139) =  297.27
       Model |    11.74713     7  1.67816142           Prob > F      =  0.0000
    Residual |  .784692955   139  .005645273           R-squared     =  0.9374
-------------+------------------------------           Adj R-squared =  0.9342
       Total |  12.5318229   146  .085834404           Root MSE      =  .07514

------------------------------------------------------------------------------
SFHomePriceIndex_log~d |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    CPIAUCNS_detrended |  -.0031605   .0049259    -0.64   0.522    -.0128999    .0065789
       CSCICP03USM665S |   .0575407    .013583     4.24   0.000     .0306847    .0843967
MORTGAGE30US_detrended |  -.3670691   .0418067    -8.78   0.000    -.4497284   -.2844098
MORTGAGE15US_detrended |   .4191084   .0375636    11.16   0.000     .3448386    .4933782
      SP500_detrended |   .0002558   .0001082     2.36   0.019     .0000418    .0004697
                 Unemp |  -.0349507    .011704    -2.99   0.003    -.0580916   -.0118097
      DLTIIT_detrended |  -.0302758   .0278663    -1.09   0.279    -.0853723    .0248208
                 _cons |  -5.307202   1.346493    -3.94   0.000    -7.969457   -2.644947
------------------------------------------------------------------------------
```

- Adjusted R-squared: 0.937
- Prob > F = 0.0000. The model is statically significant: null hypothesis is rejected.

The R squared of each model from a-d is very good: ranging from 88% to 93%. All the models are statistically sound. They best way to choose one here is to look at the endogenous variables. As mentioned in the data collection and sources, two of my variables came seasonally adjusted. They are:

- Consumer opinion confidence indicators (CSCICP03USM665S)
- Unemployment rate.

In my opinion, this creates an issue. In model a) and b), the inclusion of t should take care of the seasonality. Since those are already detrended from source, we are facing an issue. Therefore for consistency, I want to focus on models c) and d).

Out of these 2, I want to take a closer look at model c). In model d), two of my variables may not be statistically significant:

- CPIAUCNS_detrended, P-value of 0.522
- DLTIIT_detrended, P-value of 0.279

2) **Discussion of assumptions:**

Model C equation:

- SanFranciscoHomePriceIndex_log_detrended $_t$ = -755.21 -1.735 CPIAUCNS_detrended +8.14 CSCICP03USM665S - 24.9 MORTGAGE30US_detrended + 50.39 MORTGAGE15US_detrended + 0.031 SP500_detrended -5.01 Unemp -15.50 DLTIIT_detrended

The classical assumptions for unbiased OLS are:

a) **TS1: Linear in parameters:** given the equation above, we can say that SanFranciscoHomePriceIndex_log_detrended $_t$ is a linear function of the 7 endogenous variables adjusted with their respective coefficients, as well as an intercept of -755.21.

b) **TS2: No perfect collinearity**: This assumption is worrisome. I suspect the variables MORTGAGE30US MORTGAGE15US to be collinear. I ran a regression on them:

```
. regress MORTGAGE30US_detrended  MORTGAGE15US_detrended

      Source |       SS       df       MS              Number of obs =     291
-------------+------------------------------           F(  1,   289) =  183.04
       Model |  95.3563388     1  95.3563388           Prob > F      =  0.0000
    Residual |  150.560166   289  .520969433           R-squared     =  0.3878
-------------+------------------------------           Adj R-squared =  0.3856
       Total |  245.916505   290  .847987948           Root MSE      =  .72178

------------------------------------------------------------------------------
MORTGAGE30U~d |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
MORTGAGE15U~d |   .8672809   .0641049    13.53   0.000     .7411092    .9934525
        _cons |  -.1824946   .0423116    -4.31   0.000    -.2657726   -.0992166
------------------------------------------------------------------------------
```

This R squared of almost 40% show that they are related in some way. I will have to consider dropping on of them. Given that the 30 mortgage rate variable was non-significant in my models a) and b), I decided to drop that one.

c) **TS3: strict Exogeneity**: **E(εt | X) = 0.** The mean of the error term is unrelated to the values of the explanatory variable for all period.

This assumption could potentially fail. Indeed a value such as the index of the SP500 error term could be related to the value of that explanatory variable for the previous periods.

If a), b) and c) are respected, then the theorem for unbiaisness of OLS stands true.

<u>The classical assumptions for Consistent OLS are:</u>

a) **TS1: Linear in parameters:** already taken care of in the unbiased section above.
b) **TS2: No perfect collinearity**: already taken care of in the unbiased section above.
c) **Contemporaneous exogeneity**:

This follow the same concept as strict exogeneity but is not as demanding. This could still be violated.

Note: Consistency matters more for very large datasets. Here, I do not believe we have enough observations for it to be relevant.

3) <u>Final model:</u>

```
. regress SFHomePriceIndex_detrended CPIAUCNS_detrended CSCICP03USM665S    MORTG
> AGE15US_detrended SP500_detrended Unemp DLTIIT_detrended

      Source |       SS       df       MS              Number of obs =     147
-------------+------------------------------           F(  6,   140) =  235.09
       Model |  203853.256     6  33975.5427           Prob > F      =  0.0000
    Residual |  20233.1796   140  144.522712           R-squared     =  0.9097
-------------+------------------------------           Adj R-squared =  0.9058
       Total |  224086.436   146  1534.8386            Root MSE      =  12.022

------------------------------------------------------------------------------
S~x_detrended |     Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
CPIAUCNS_de~d |  -1.928433   .7864455    -2.45   0.015    -3.483278   -.3735885
CSCICP03~665S |   11.68586   1.955155     5.98   0.000     7.820409     15.5513
MORTGAGE15U~d |   34.13585   4.138844     8.25   0.000     25.95314    42.31857
SP500_detre~d |   -.026464    .007978    -3.32   0.001    -.0422368   -.0106911
        Unemp |  -10.16944   1.262994    -8.05   0.000    -12.66645   -7.672434
DLTIIT_detr~d |  -18.27029   4.396461    -4.16   0.000    -26.96233   -9.578246
        _cons |  -1083.821   196.6211    -5.51   0.000    -1472.551   -695.0905
------------------------------------------------------------------------------
```

Final equation of causal regression:

- SanFranciscoHomePriceIndex_log_detrended $_t$ = -1083.8 -1.92 CPIAUCNS_detrended +11.64 CSCICP03USM665S + 34.13 MORTGAGE15US_detrended - 0.026 SP500_detrended -10.16 Unemp -18.27 DLTIIT_detrended

Adjusted R squared: 90%.

We removed the variable MORTGAGE30US_detrended due to a collinearity issue.

Prob > F = 0.0000. The model is statically significant: null hypothesis is rejected.

V) forecasting model

1) For February 2016:

In order to forecast future unobserved values, I will use the regression I found in part IV) as it is the best indicator for the given SF home price index given the period t. For forecasting, we will also include lagged variables in the model.

```
. regress SanFranciscoHomePriceIndex lag4CPIAUCNS_detrended lag4CSCICP03USM665S lag4MORTGAGE15US_detrended lag4SP500_detrended lag
> 4unemp lag4DLTIIT_detrended lag4SanFranciscoHomePriceIndex

      Source |       SS       df       MS              Number of obs =     147
-------------+------------------------------           F(  7,   139) =  507.21
       Model |  146261.132     7  20894.4474           Prob > F      =  0.0000
    Residual |  5726.07982   139  41.1948188           R-squared     =  0.9623
-------------+------------------------------           Adj R-squared =  0.9604
       Total |  151987.211   146  1041.0083            Root MSE      =  6.4183

------------------------------------------------------------------------------------------------
    SanFranciscoHomePriceIndex |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------------
        lag4CPIAUCNS_detrended |   .4154079   .4382582     0.95   0.345    -.4511065    1.281922
           lag4CSCICP03USM665S |   5.368582   1.056936     5.08   0.000     3.278831    7.458334
    lag4MORTGAGE15US_detrended |  -11.66538    2.73509    -4.27   0.000    -17.07314   -6.257625
           lag4SP500_detrended |  -.0123924    .005278    -2.35   0.020    -.0228279   -.0019569
                     lag4unemp |   1.469612    .674511     2.18   0.031     .1359843    2.803241
          lag4DLTIIT_detrended |   4.290186   2.587413     1.66   0.100     -.825589    9.405961
lag4SanFranciscoHomePriceIndex |   1.090402   .0466162    23.39   0.000     .9982333     1.18257
                         _cons |  -557.0177   105.3003    -5.29   0.000    -765.2151   -348.8203
------------------------------------------------------------------------------------------------
```

This regression is calculated using lagged variables: the prefix lag4 corresponds to the variable lagged 4 time units (here months) this will be useful to calculate the February 2016 value given we have observations until November 2015. The adjusted R squared is very high, meaning the regression should be solid (96%)

The forecasting equation is:

- SanFranciscoHomePriceIndex $_t$ = -557 +0.415 lag4CPIAUCNS_detrended + 5.37 lag4CSCICP03USM665S -11.66 lag4MORTGAGE15US_detrended - 0.0124 lag4SP500_detrended +1.47 lag4Unemp +4.29 lag4DLTIIT_detrended + 1.09 SanFranciscoHomePriceIndex $_{t-4}$

SanFranciscoHomePriceIndex $_{t-4}$ is included to give a recursion to the curve and bring the r squared very high. The prediction will be more accurate.

Using this equation, we can plug in the real observed values for each variable:

SanFranciscoHomePriceIndex $_t$ where t equates to Feb 2016:

= -557+ -5.1220207 *0.415 +5.37*101.95 -11.66* 0.039996 - 0.0124*375.23099 +1.47*5 +4.29*0.53590816 + 1.09 *218.4

=230.9317

Using this model, I predict the Sf home index to be around 230. Given that the index has a value of 218.4 as of November, this value seems realistic.

2) **For October 2016:**

Here, I will have to lag the variables 11 months in order to be able to predict the value of the SF home price index in October 2016.

```
regress SanFranciscoHomePriceIndex lag11CPIAUCNS_detrended lag11CSCICP03USM665S lag11MORTGAGE15US_detrended lag11SP500_detrended
 lag11unemp lag11DLTIIT_detrended lag11SanFranciscoHomePriceIndex

      Source |       SS       df       MS              Number of obs =     144
-------------+------------------------------           F(  7,   136) =   98.05
       Model |  131307.405     7  18758.2007           Prob > F      =  0.0000
    Residual |  26017.2131   136  191.303038           R-squared     =  0.8346
-------------+------------------------------           Adj R-squared =  0.8261
       Total |  157324.618   143  1100.17216           Root MSE      =  13.831

------------------------------------------------------------------------------------------------
    SanFranciscoHomePriceIndex |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------------------+----------------------------------------------------------------
       lag11CPIAUCNS_detrended |   1.151147   1.009731     1.14   0.256    -.8456586    3.147952
          lag11CSCICP03USM665S |   5.775127   2.321563     2.49   0.014     1.184095    10.36616
   lag11MORTGAGE15US_detrended |  -40.25463   6.000848    -6.71   0.000    -52.12168   -28.38759
          lag11SP500_detrended |  -.0357265   .0125208    -2.85   0.005    -.0604871   -.0109659
                    lag11unemp |  -2.053444   1.471771    -1.40   0.165     -4.96396    .8570719
         lag11DLTIIT_detrended |   15.46879   5.650077     2.74   0.007     4.295419    26.64216
ag11SanFranciscoHomePriceIndex |   1.159941   .1015957    11.42   0.000      .959029    1.360852
                         _cons |  -584.2536   231.5602    -2.52   0.013    -1042.178   -126.3291
------------------------------------------------------------------------------------------------
```

This regression is also calculated using lagged variables: the prefix lag11 corresponds to the variable lagged 11 time units. The adjusted R squared is not quite as high as in the 4 months lagged example but still high (82%) I think we can still use this to get an idea of the prediction.

- SanFranciscoHomePriceIndex $_t$ = -584.25 +1.15 lag11CPIAUCNS_detrended + 5.77 lag11CSCICP03USM665S -40.25 lag11MORTGAGE15US_detrended - 0.0357 lag11SP500_detrended -2.05 lag11Unemp +15.46 lag11DLTIIT_detrended + 1.16 $SanFranciscoHomePriceIndex_{t-11}$

Using this equation, we can plug in the real observed values for each variable:

$SanFranciscoHomePriceIndex_{t}$ where t equates to October 2016:

$= -584.25 + 1.15 * -5.1220207 + 5.77 * 100.9513413687 - 40.25 * 0.039996 - 0.0357 * 375.23099 - 2.05 * 5 + 15.46 * 0.5359082 + 1.16 * 218.4$

$= 228.7225$

Again, the value of the estimate is in appearance consistent with a possible index value. We notice a slight decrease from February to October.

Additional sources

Moody's case Shiller methodology: http://www.moodysanalytics.com/~/media/Brochures/Economic-Consumer-Credit-Analytics/Examples/case-shiller-methodology.pdf

Consumer price index handbook: http://www.bls.gov/opub/hom/pdf/homch17.pdf

S&P indices: http://us.spindices.com/indices/

Treasury yield information: http://www.investopedia.com/terms/t/treasury-yield.asp