Methods and Applications of Analysis.
Vol. 24, No. 1, pp. 001–010, March 2017

SEASONALITY IN UNITED STATES HOME PRICES*

HENRY LAUFER†

Abstract. We present the slides from a talk about Wall Street and about seasonality in United States home prices. Seasonality is approached via two non–standard paths: for prices we use initial listed prices, for seasonality we use easy Fourier analysis. Prices peak at the end of May. The amplitude of the seasonal change is large in recent years: 5.3%. There is a similar seasonality in the areas of listed homes. But the amplitude of the area change is much smaller: 1.9%. The price seasonality is uniform throughout most of the United States.

Thank you very much for honoring me at this conference.

First, I am going to spend a little time reviewing my personal history.

Then, in order to give some flavor of the type of work that I used to do in finance, I shall give a slightly technical talk about home prices.

The math here is very elementary, just some baby Fourier series. The hard work is in organizing the data.

Question:
How do you make a small fortune trading gold?

Answer:
Start with a LARGE fortune.

Question:
How to Become a Wall Street Quant in Five Easy Steps

Answer:
1) Have a friend already on Wall Street.
2) Play poker with him.
3) Know computer programming.
4) Timing.
5) Give up security/tenure and accept the job offer.

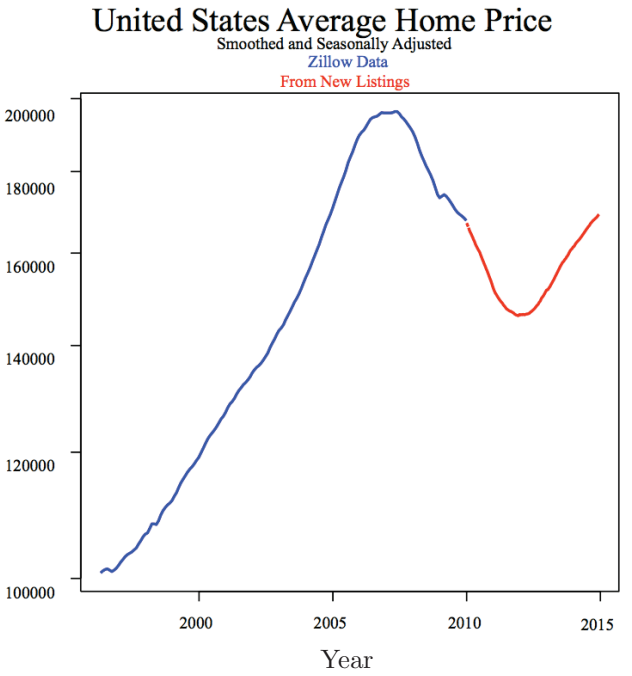
We now turn to United States home prices.

References and Resources. [1]

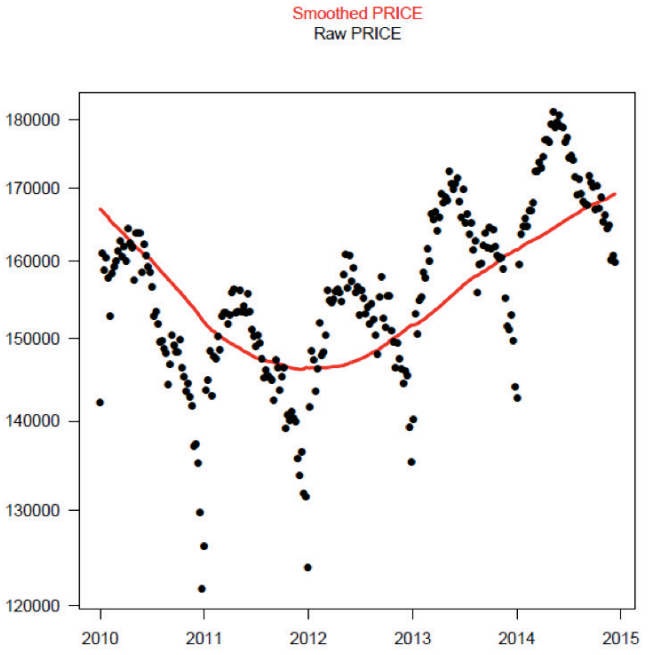
- Case–Shiller (Housing) Index: Karl Case and Robert Shiller
- Zillow - Real estate web site
- Trulia - Real estate web site
- Altos Research - Real estate web site & data source
- Elliot Anenberg and Steven Laufer, 'Using data on Seller Behavior to Forecast Short–run House Price Changes'
- Norm Miller et. al., 'Correcting for the Effect of Seasonality on Home Prices'

*Received March 16, 2016; accepted for publication October 13, 2016.
†Renaissance Technologies, Chief Scientist (retired).
[1]The author is deeply grateful to Gert-Martin Greuel for transcribing the author's poorly organized slides into the first draft of this article.

Here are home prices since 1995. The blue represents prices from Zillow. The red is an extension since 2010 using smoothed listed prices. The un–shown Zillow prices in this same period would closely match the extended prices shown in red.



Now we repeat the smoothed recent prices, in red, and overlay in black dots the raw weekly data. The red smoothing is the yearly moving average of the black dots data.



We are going to do an easy Fourier analysis of the raw prices.

$F_N(t)$, the N^{th} Seasonal Fit is defined via:

$t \in [0, 5 \cdot 2\pi) = \text{Date} \in [1 \text{ January } 2010, 1 \text{ January } 2015)$

$P(t) = \log(\text{PRICE(Date)})$

$$F_N(t) = a_0 + \sum_{n=1}^{N} (a_n \cos(nt) + b_n \sin(nt))$$

$$a_n = \sum_t P(t) \cos(nt) / \sum_t \cos^2(nt)$$

$$a_0 = \sum_t P(t) / \sum_t 1 = \text{ mean } (P(t))$$

$$b_n = \sum_t P(t) \sin(nt) / \sum_t \sin^2(nt)$$

Set a_0 to 0 to form the N^{th} seasonal adjustment.

The usual amplitude and phase are given by:

$$a_n \cos(nt) + b_n \sin(nt) = A_n \sin(nt + \phi_n)$$

$A_n = \sqrt{a_n^2 + b_n^2}$	A_n is the amplitude.
$\tan(\phi_n) = a_n / b_n$	ϕ_n is the phase.

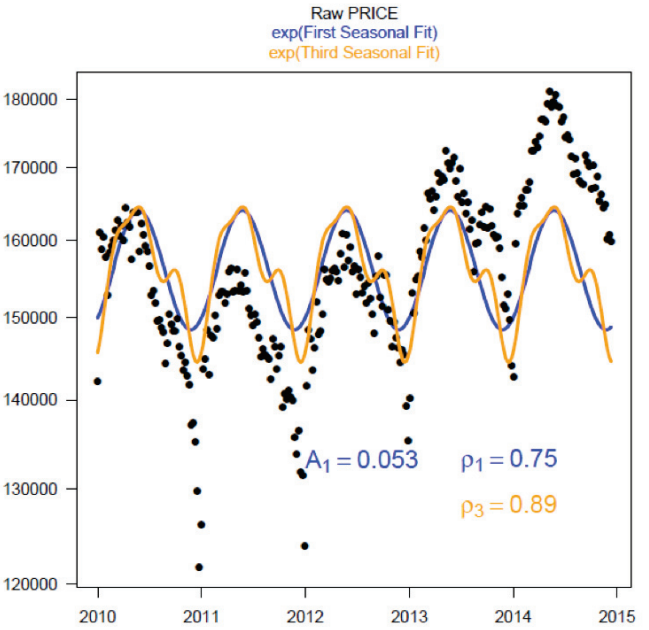
We introduce a goodness of fit measurement ρ_N as follows:

Yearly_Reset $(P(t))$ is a non–standard operation to remove long term trends:

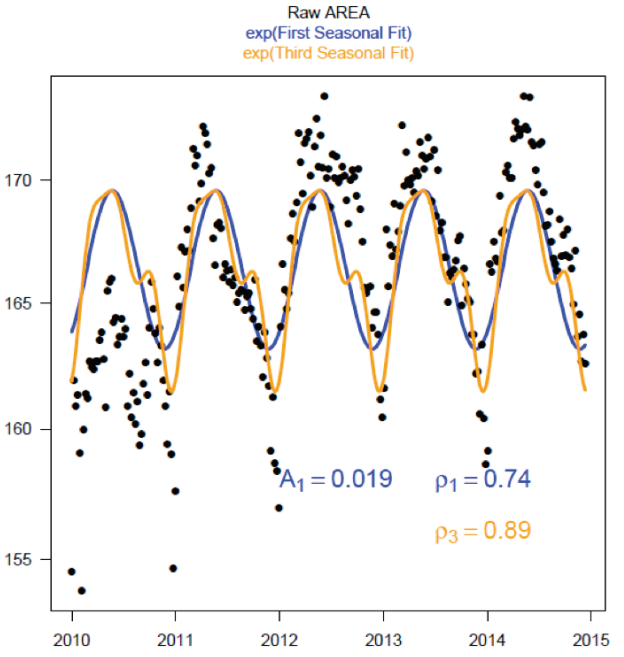
Each year, subtract off the yearly mean of $P(t)$.

$\rho_N = \text{correlation } (F_N(t), \text{ Yearly\_Reset } (P(t)))$

We overlay the previous graph of raw weekly home prices with the first and third seasonal fits.



Besides looking at prices of homes, in US dollars, we can also look at areas of homes, in square meters.



The graph for home prices and the graph for areas are remarkably similar. But the amplitudes of the adjustments are very different:

For PRICES: $\mathbf{A_1 = 0.053}$
For AREAS: $\mathbf{A_1 = 0.019}$

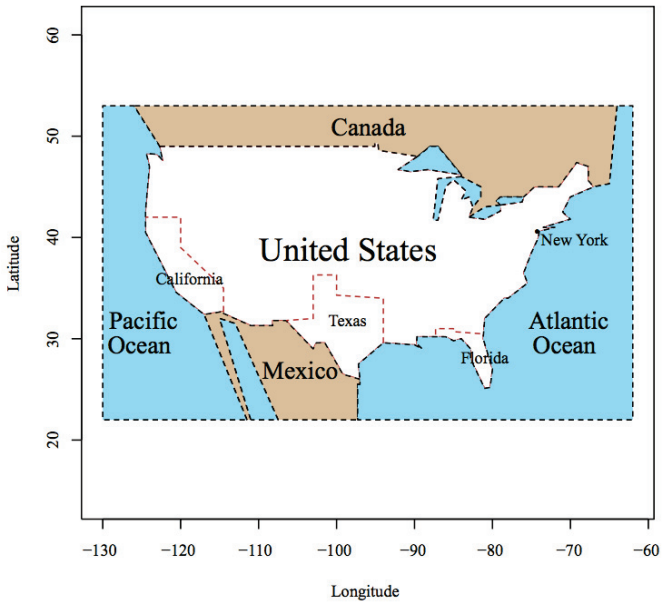
Be sure to look at the vertical scales.

Question:
Does a fixed home really vary periodically in price?
Or could it just be that offered homes vary periodically in quality?

Answer:
Perhaps some of both.

So far, we have considered home prices only over time.

But prices also vary over space. In fact, the three most important factors in determining a home's price are
location,
location,
location.



We partition the United States, excluding Alaska and Hawaii, into sixty regions.

Nineteen of these regions are metropolitan areas (large cities with their surroundings), such as New York or Washington.

The other forty-one regions are single states or small groups of adjacent states, with the nineteen metropolitan areas omitted.

The average price by region, shown nearby, is the 0^{th} term in the seasonal fit.

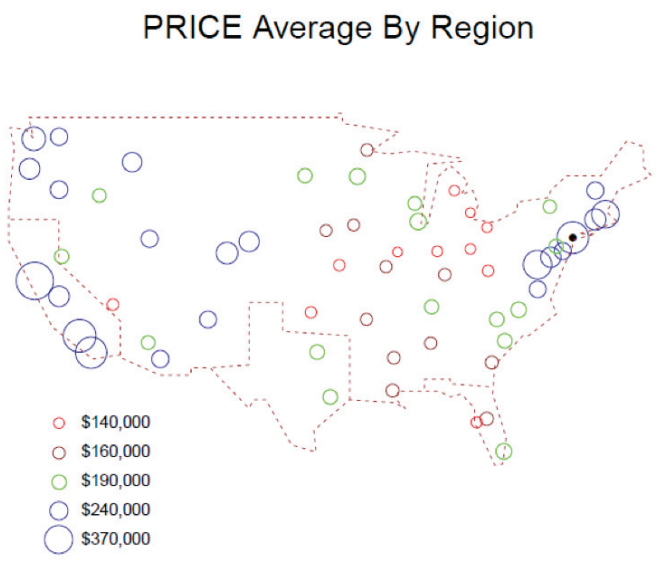
By region, we will compute and display the first terms in the seasonal fit/adjustment.

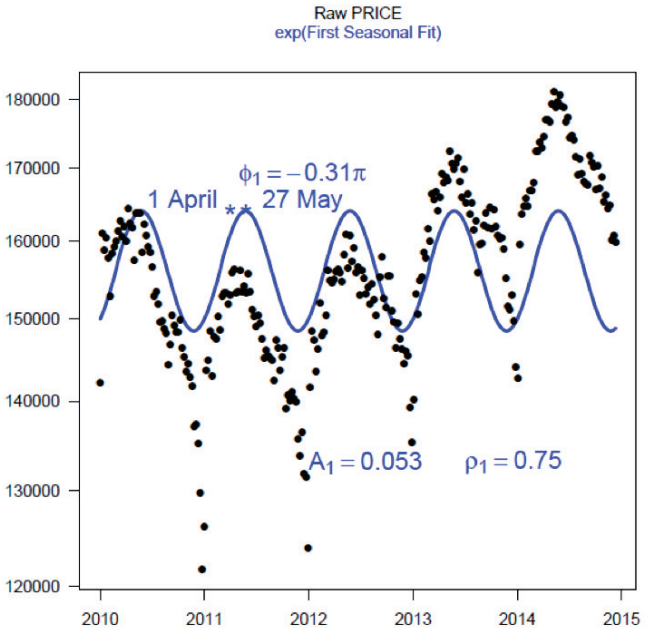
We are going to need a compact summary of these first terms.

We start by reviewing the first adjustment for all of the United States.

Then we will repeat the computation for each region.

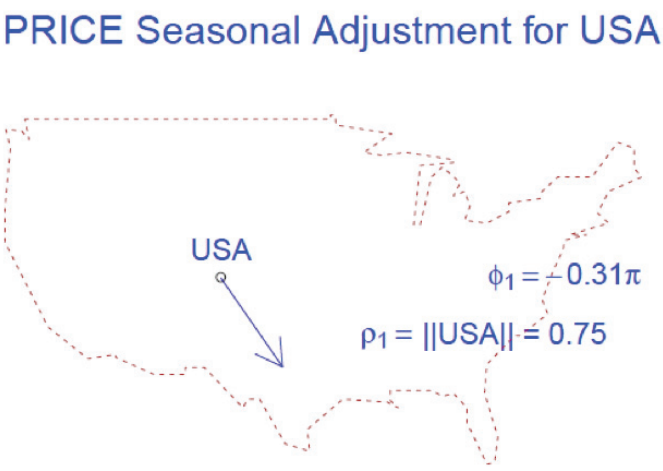
Recall: $a_1 \cos(t) + b_1 \sin(t) = A_1 \sin(t + \phi_1)$.





Vector Display of First Seasonal Adjustment. Draw a (blue) adjustment vector, named USA, at an angle of ϕ_1 and of length ρ_1.

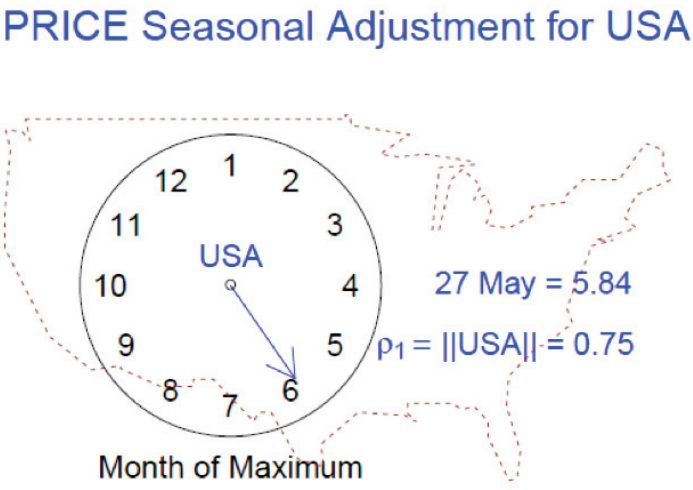
Results would be very similar if instead of 'length ρ_1', which measures the goodness of the fit, we used 'length A_1', which is the amplitude of the first seasonal adjustment.

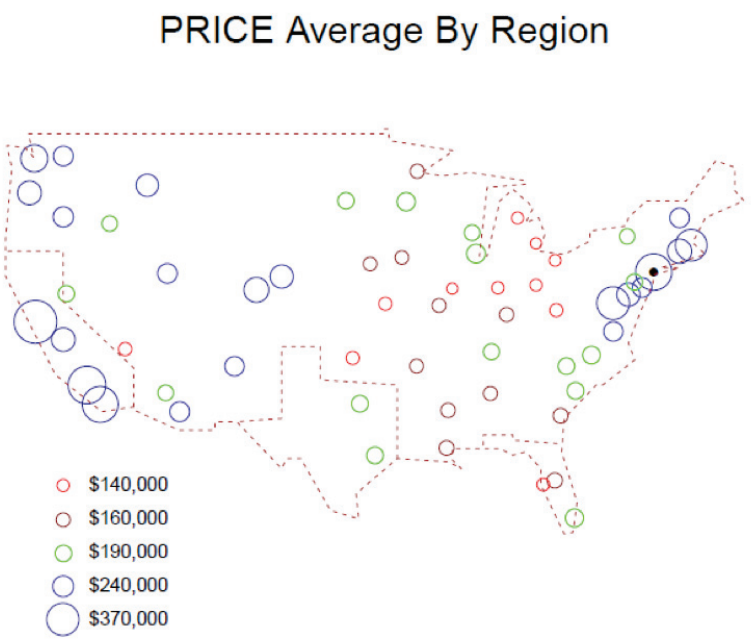


Additionally, super-impose a rotated unit clock so that the adjustment vector points at the month of the maximum.

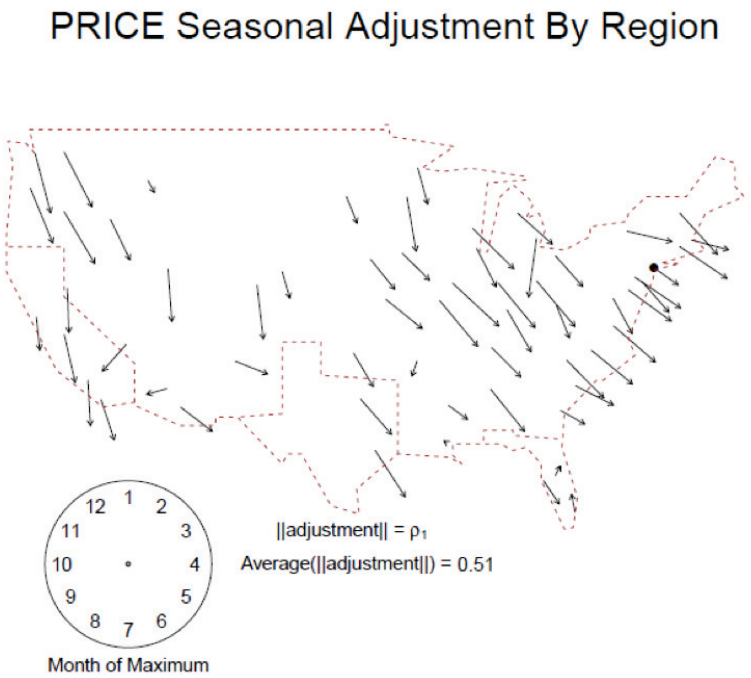
May is the 5th month, with 31 days.

27 May = 5 + (27-1)/31=5.84





We have just shown the central location of the sixty regions via a repeat of the map of prices.

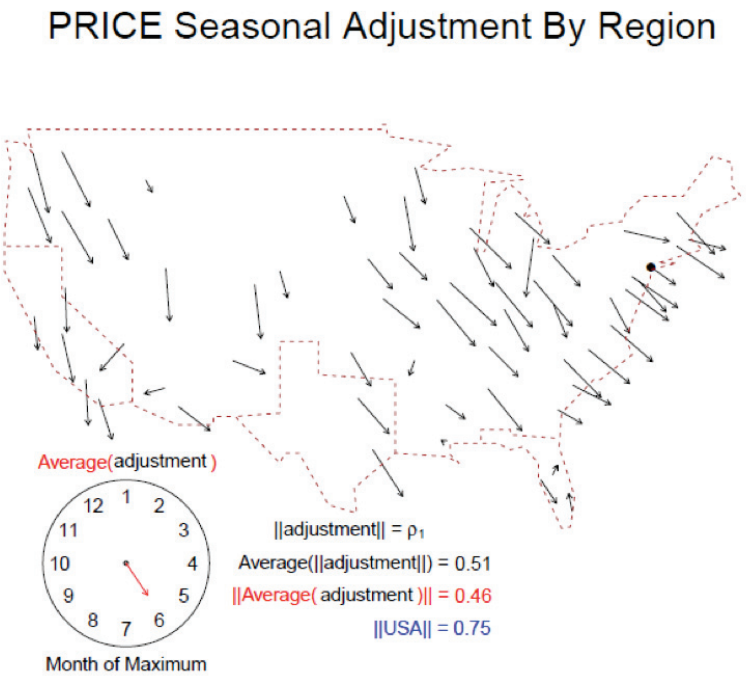


Now compute the first seasonal adjustment for each region, as was previously done in blue for the entire United States.

Display the regional adjustment vectors in black. Include a single rotated unit clock.

Also display in red, using the clock, the average of the regional adjustment vectors.

This red average adjustment vector and the (non-displayed) previous blue United States (USA) adjustment vector represent nearly equal phases, but do have different lengths.



Observe that the vast majority of the regions have very similar seasonal adjustments. Two exceptions are in the state of Florida, in the lower right hand corner. This may be due to the warm winter weather in Florida and also to its large number of retired residents, who ignore the seasonality of the children's school year.