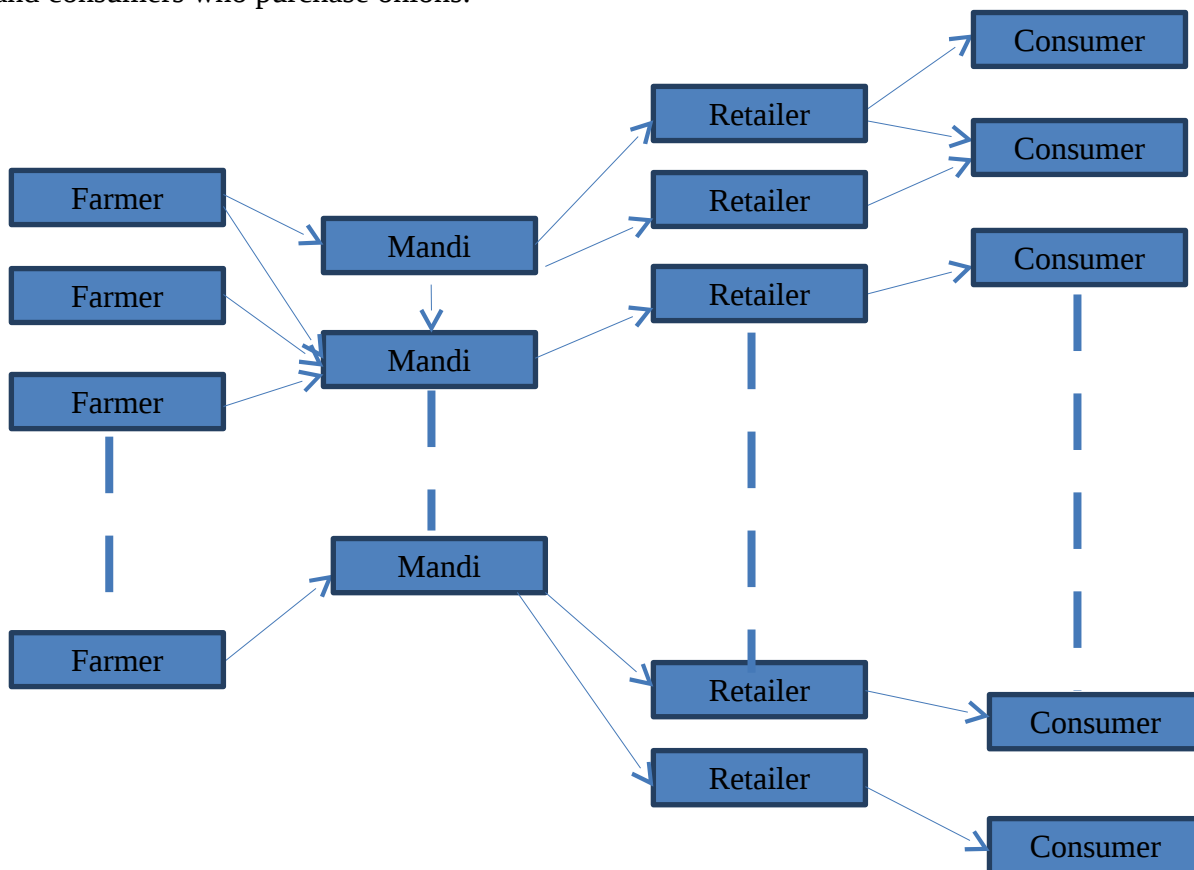


Problem Statement

Supply demand imbalance, natural calamities etc. may not always be the reason behind the rise in the price of a commodity. It may be a result of artificial supply deficit planned intelligently by traders' nexus to earn more profits through manipulation of supply of commodity and hence indirectly controlling their prices. Our attempt is to locate such hikes in prices which seem suspicious (we call them anomalies).

Data we have

For now, we are only working over onion data. We have three actors in model: Farmers who are producers of onion, traders who are collectively responsible for supply of onions across countries and consumers who purchase onions.



Farmers sell their produce to traders in nearest mandi offering better price. These traders sell these commodities to traders in other mandis or to retailers. Consumers purchase commodities for consumption from one of the retail stores. This way commodity reaches consumers from farmers following a huge chain of traders and retailers.

We have following data:

1. "Arrival of onion" data across **1500** mandis of country for every day since 2006.
2. Min, Max and modal wholesale price of onion traded in these mandis for every day since 2006
3. Retail prices of onion in 70 centres(major cities) across country
4. Longitude and latitude of mandis and centres

Normal market behaviour:

1. Wholesale price is inversely proportional to arrival of commodity –higher production of crop will lead to more and more crop hitting market for sell. Hence more arrival which will result in surplus supply leading to drop in wholesale prices.
2. Retail price is directly proportional to wholesale price – commodities reach customers through a long chain of traders and retailers, adding value at every stage of chain. So, retail price at which customers purchase commodities are more than wholesale.

Any divergence from these characteristics of normal market leads to suspicious price hike situations/anomalies.

What are the reasons for anomaly?

Primarily there are 3 main reasons of anomaly.

1. Government Policies: When the price is low in the country, still government allows the export of onion in large amount, or supports it by keeping low minimum price then the prices can rise up drastically.
2. Unseasonal Rainfall: Due to insufficient rainfall, heavy rainfall or unseasonal rainfall, onion crop may get affected and the produce is low and wholesale price may rise up. But, this reason still is validating that wholesale price is inversely proportional to arrival, it may be just prices will be little higher than it was supposed to be.
3. Hoarding: When traders/wholesalers store the onion and does not release the stock in the market in the expectation of the good prices in the future, it will create the artificial deficit in the market and will shoot up the onion prices in the retail market due to low arrival in the retail market. The reason people do this is to expect the higher prices in the time of low production or may be for security. For example, if it is expected that this year the rainfall will be very low, then people may think that, due to that, production will be low in the future and so they will start storing onion right now and that will also create deficit in the market and price will go up.

So our study will focus on detection of anomalies in data and if possible comment on the possible reason for the anomaly.

How to detect anomaly?

To detect the anomaly we need to look at the data and look at the behaviour of it during the overall time-period. During the anomaly, its behaviour will be the different than the usual.

Now, what is called as hoarding, is not defined anywhere or even when we can say that there may be the case of an anomaly or particularly hoarding is not defined anywhere. So to approach this question we tried the following method...

To answer this question, we went through the series of the news articles when the hoarding is in the news. Then looking over those articles, we try to see that why they are reporting to news, what happened so that people are giving it name of hoarding and how reporters are making conclusion that it may be the class of the hoarding.

Summary of news articles

First such incident was reported in the 1998. The article [1] dated on 21st September 1999 states as follows:

“Onions were retailed at Rs 6 a kilo two weeks back. Today, the price was almost 100 per cent up, hovering in the Rs 10-12 band in different parts of the country.”

So this article is comparing the retail price of today with the price before 2 weeks. The rise upto 100% is what has come to notice. Also article says that,

“There is talk in the market that the government is likely to lift the ban on onion exports. Apparently, some traders are resorting to hoarding in anticipation of demand from markets abroad.”

As stated previously also, government policy also plays a major role in this.

After that Onion was in news in 2010. NDTV [2], TOI [3] and many more reported the incident. In 2010, unseasonal rainfall and the government policy on export price were also the reason for hike in the price. The report dated Dec 23, 2010, TOI states the follows (in Delhi):

“On Tuesday alone, wholesale traders in Delhi bought onions at about Rs 34 per kg while it was sold in retail at Rs 80 per kg. That's a margin of Rs 46 per kg or 135%!”

Here, they have compared the difference between the wholesale price and the retail price. The margin of 135% is reported. When we looked into data we have, we got the following results for Dec, 2010.

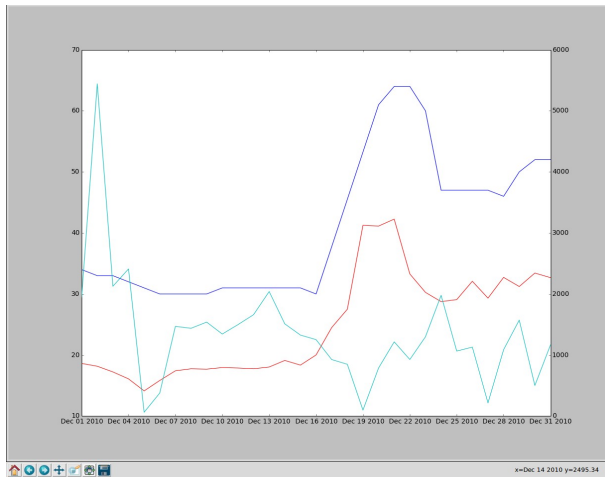


Figure 1: Delhi, Dec 2010. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

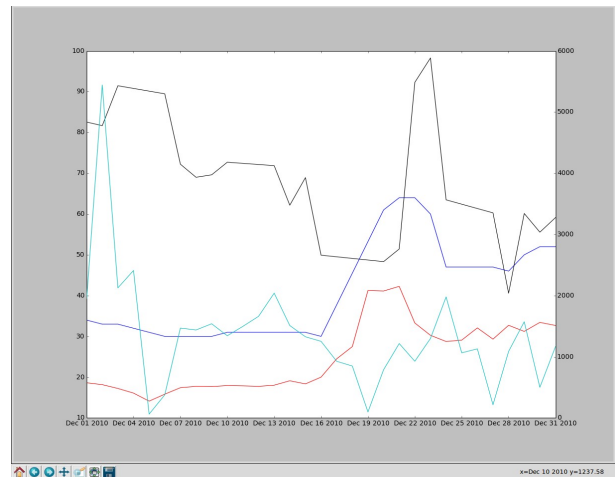


Figure 2: Delhi, Dec 2010. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival, Black - Relative difference %)

So, as per our data, the maximum price difference observed was of $\sim 100\%$. Note that the retail prices we have is the minimum price observed in the market.

NDTV on Dec 22, 2010 reported the following (NASIK):

"The average purchase rate of a trader here is about Rs. 3,000, but they go to the cities and claim it's nearly Rs. 8,000 and that's how the rates go up. It's all the fault of the traders. They loot the people," said Sangdeorao Holkar, Director, National Agricultural Cooperative Marketing Federation of India.

Here also, as we see they have mentioned price difference between retail and wholesale in the market. It is approximately ~ 166%.

Report also adds the following:

"The government, on a back foot, banned exports last evening. In less than 24 hours, prices in Lasalgaon crashed by 25 per cent.

Navi Mumbai:: Wholesale price

Tuesday: Rs. 60 per kg

Wednesday: Rs. 45 per kg

And this is finally what the consumer in Mumbai is paying:

Mumbai: Retail price

Tuesday: Rs. 6

0 to Rs. 70 per kg

Wednesday: Rs. 60 to Rs. 70 per kg"

So as we can see, there is significant drop in the wholesale price, but no drop in the retail price, so that has been reported. Also difference in the hike in retail price, from 40 to 60 was reported in on week. What our data says:

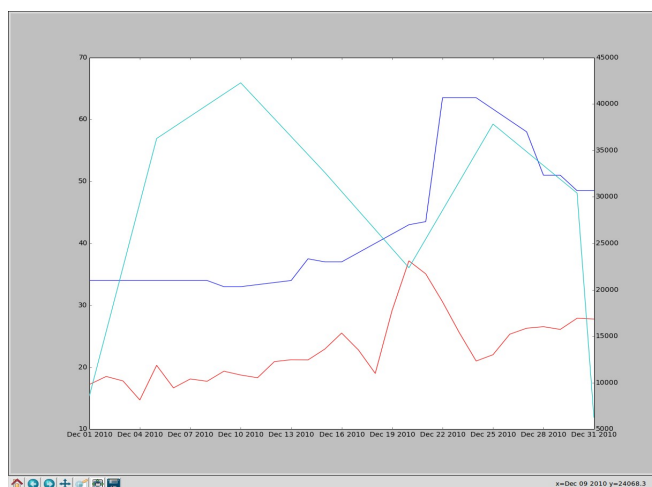


Figure 4: Maharashtra, Dec 2010. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

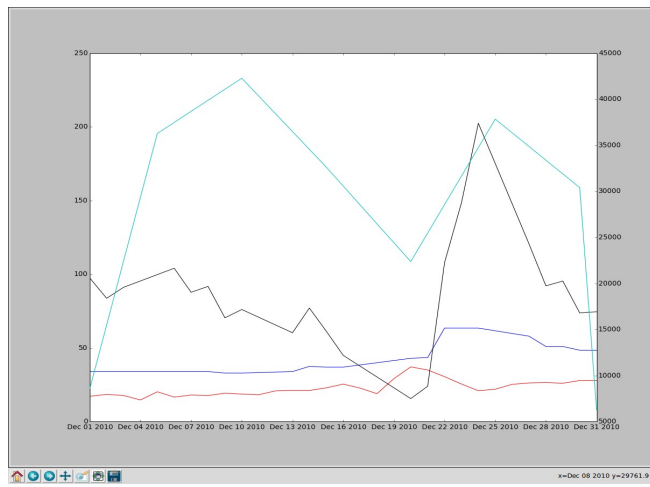


Figure 3: Maharashtra Dec 2010. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival, Black - Relative difference %)

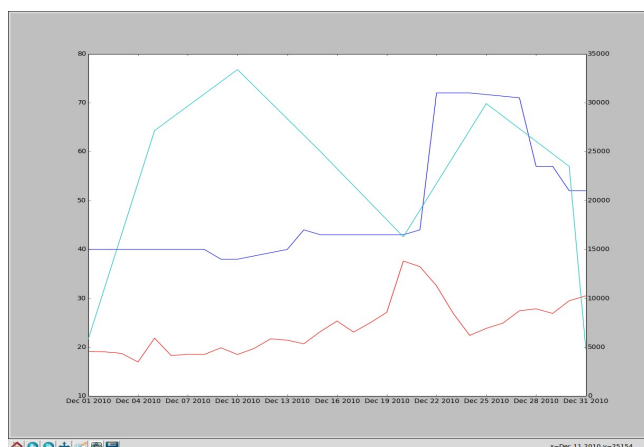


Figure 6: Mumbai, Dec 2010. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

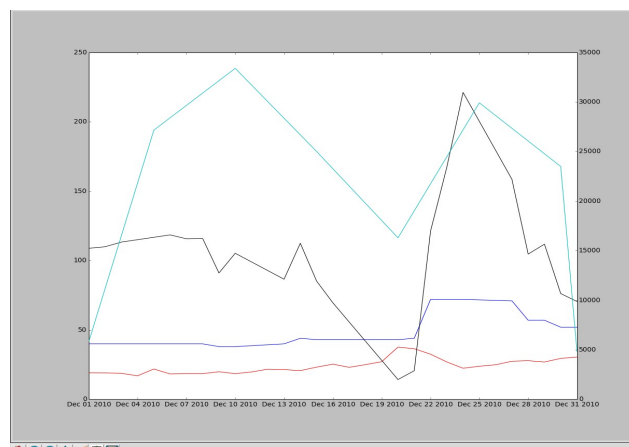


Figure 5: Mumbai, Dec 2010. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival Black - Relative difference %)

As we can see from the Figure 3, 4, 5 and 6, the difference between retail and wholesale went as much high as 200% in both overall Maharashtra as well as in the Mumbai. Also, as per report [4], this trend was also continued in the next month, i.e. January 2011, which can be seen in the following graph.

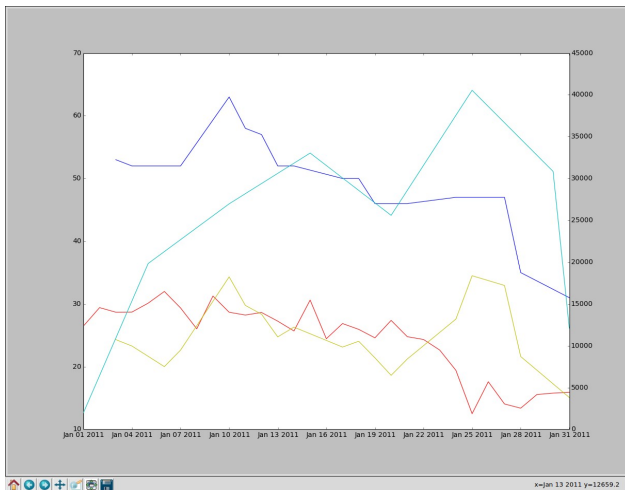


Figure 8: Mumbai, Jan 2011. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

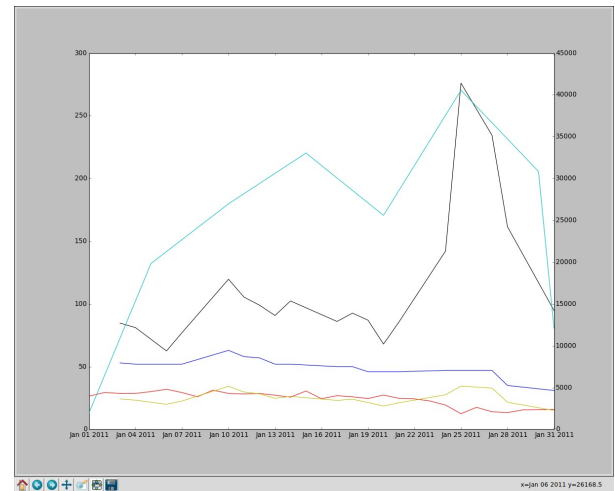


Figure 7: Mumbai, Jan 2011. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival Black - Relative difference %)

Next hoarding news was reported in the last week July 2013. As per the Business Standard Report [5],

“Onion prices in Nashik, Pune and Ahmednagar have increased to Rs 2,400 a quintal as on July 21, compared to Rs 1,500-1,800 a quintal during the corresponding period of last year. Arrival of onions in Nashik, which contributes 35-40 per cent to the state production, has been 83,000 quintals compared with 82,000 quintals last year”

Also, in the 2013, in the month of August, September and October, the price rise of the Onion in various parts of countries like Bangalore ([6]), New Delhi ([7],[8],[9]) and Gandhinagar ([10]) was in the news. Reports of Bangalore and New Delhi has just reported the hike in the retail price. DNA report on Gandhinagar says,

“Retail onion prices in the city have increased from around Rs40/kg, a month ago, to Rs70/kg on Saturday. In the wholesale market, onion prices have increased around Rs35 per kg till last week to Rs45 per kg on Saturday. The wholesale price is Rs.40 to 45 per kg. Ideally, in the retail market the price should not be more than Rs.60 per kg”

Let's look at the data we have. As from the figure 9 and 10, the wholesale rates around the mandis present around the Mumbai in the month of July, 2012 was about Rs. 5/Kg, but during the same time period in the 2013, the wholesale prices went from Rs. 15/Kg to Rs. 25/Kg. Although, there was decrement in the arrival by 7% as compared to July 2012, but the rise in the wholesale price is very much high.

Figure 11 and 12, states the scenario of Gujarat. There also the wholesale as well as the retail prices became suddenly almost double in the month of August 2013.

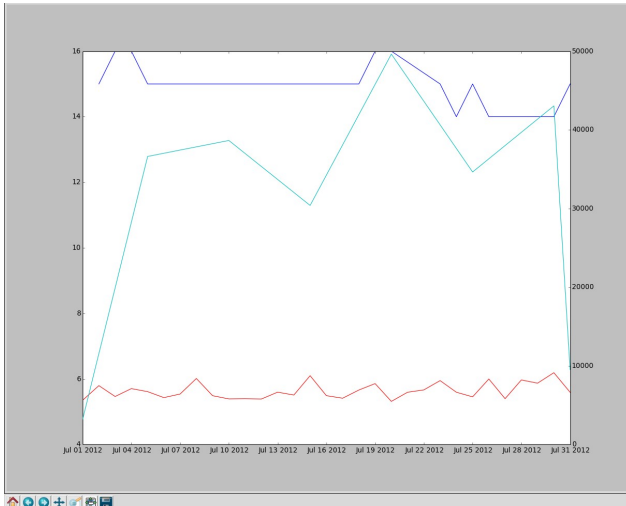


Figure 9: Mumbai , July 2012. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

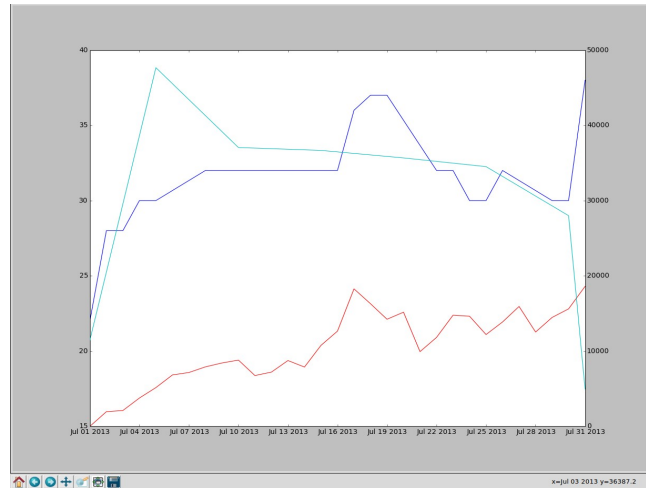


Figure 10: Mumbai , July 2013. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

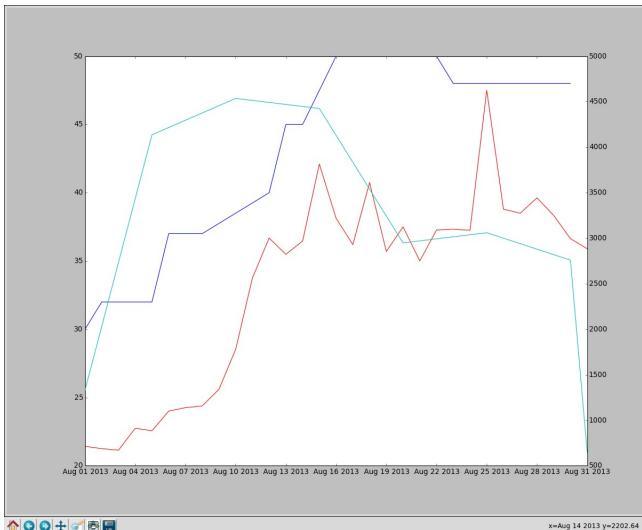


Figure 11: Ahmedabad , Aug 2013. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

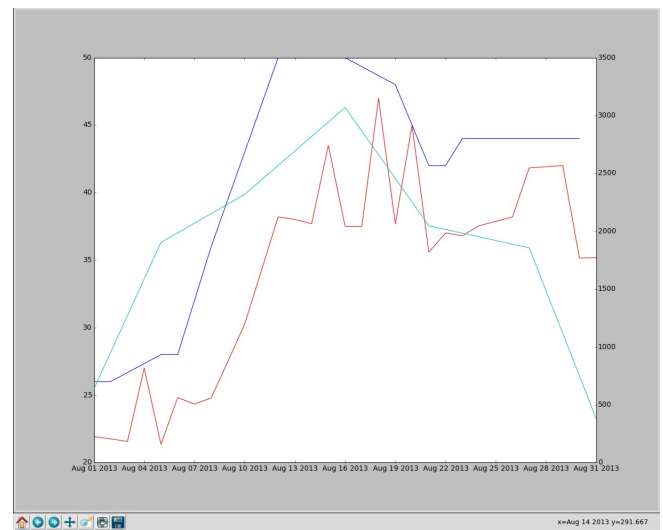


Figure 12: Rajkot , Aug 2013. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

Also, in year 2014, price hike of Onions was in the news. There were reports from Mumbai [11], Kerala [12] and Hydrabad [13] which stated the hike in the prices of the onion. Let's look at the graph of the Mumbai for the year of 2014. As we can see from that graph (Figure 13) that for the period of July to October the wholesale price were decreasing, but still that was not reflected in the retail price and instead of decreasing, the retail price kept on increasing.

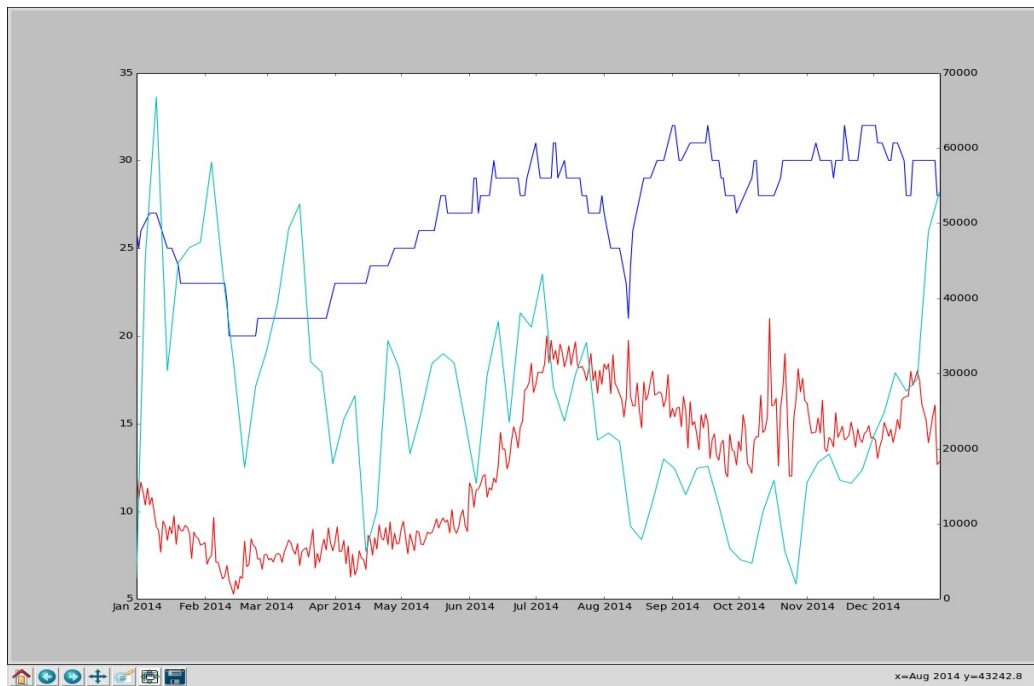


Figure 13: Mumbai , 2014. (Blue - Retail price, Red - Wholesale Price, Cyan - Arrival)

Characteristics of anomaly

Hoarding of commodities in excess, results in anomaly. We segregated news articles on hoarding of onion and tried to spot some characteristics of data for anomalies.

So, major characteristics of hoarding spotted in newspapers are following:

1. Huge difference in wholesale and retail prices
2. Sudden rise in wholesale or retail price
3. Rise in wholesale prices when arrival is enough/high

The years where hoarding data were reported are: 2010, 2013, 2014 and 2015. For rest years no such hoarding news were reported.

Methodology

Since retail data of commodity is available only across 70 centres in country compared to 1400 mandis data. We'll try to find similarities among centres using time series of arrival and modal price data of surrounding mandis and time series of retail data at that centre. Using these three parameters , correlation among centres will be computed to find similarity among centres in terms of arrival, wholesale and retail price. Centres with similar trends of data will have high correlation values. We are planning to use multivariate time series analysis to find correlation matrix since it computes correlation between entities based multiple time series attributes.

The correlation values between centres will be computed using data reported in years with no hoarding new articles. This will give basis to our model. We'll assume centres to be related as indicated by this pre-computed correlation matrix.

To monitor anomalies at every centre for every day, estimated value for every centre based on this correlation matrix is computed. The value is compared with actual value and if it varies beyond a threshold, red flags need to be raised.

The estimated arrival, wholesale and retail price data is labelled up, down and constant based on if it exceeds actual data value. Red flags are raised based on the following tables if the condition falls under the category marked with **A's**.

R\W	↑	↔	↓
↑	-	A	A
↔	-	-	A
↓	-	-	-

W\A	↑	↔	↓
↑	A	A	-
↔	A	-	-
↓	-	-	-

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