1 Analysis of Methods implemented

The library has 5 methods to detect anomalies. Following table describes the method and limitations of every method:

Window Correlation	Detects if the two timeseries follows their expected behaviour or not. i.e if the two timeseries are expected to move in tandem then it reports the tenures where they don't move in tandem and vice- versa	• Result of method depends on window size. So if the anomaly occurred for very small time, it won't be reported. (See Figure 1) • Reports results even though the fluctutaions are not very prominent. (See Figure 2) the deviation in prices were not huge but incident was reported because the two timeseries moved out of tandem. • Result is also dependant on selected threshold.
Slope-Based Method	Reports incidents when one timeseries change its value faster than other.Window correlation miss the incidents when one timeseries changes its values faster than other since it just focus on the direction of change and not on rate of change. (See Figure 3)	• Result of method depends on window size. So if the anomaly occurred for very small time, it won't be reported. • Since it only checks rate of change in timeseries, it reports cases when retail prices decline to great rate than others which is ideally a good case. (See Figure 4) • Result is also dependant on selected threshold. (See Figure 5)
Linear Regression	It tries to build a linear model between two timeseries. Reports all the points which deviates much from the predicted value.	• Efficiency of method depends on to what extent two timeseries are linearly dependant. • Result is dependant on selected threshold.
Multivarite-timeseries	It also builds a vector-autoregressive model based on multiple timeseries which affect each others value.Reports all the dates which tends to deviate too much from the predicted value. Considers trend and seasonality component of timeseries..(See Figure 6)	• Result is dependant on selected threshold.
Graph Based	It considers trend and seasonality in the timeseries while building model. Reports all the dates which seems deviating much from the past data.(See Figure 7)	• Result is dependant on number of anomalous points selected.

Table 1: Description on methods

Note: Highlighted regions present in figures of this chapter represents following:
Red Highlighted Region: Anomalies reported by system and matched with news articles
Yellow Highlighted Region: Anomalies reported by system but could not be matched matched with news articles
Violet/Blue Highlighted Region: News articles present but not reported as anomaly by our system

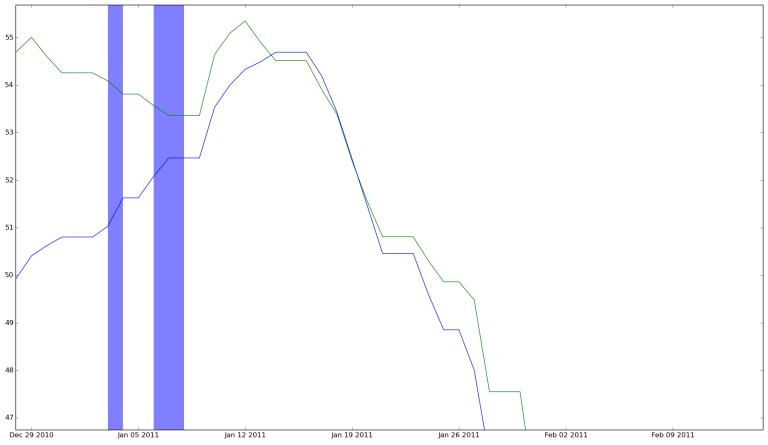

Figure 1: Window based correlation (Green line - Centre Retail Price, Blue Line - Average Retail Price)

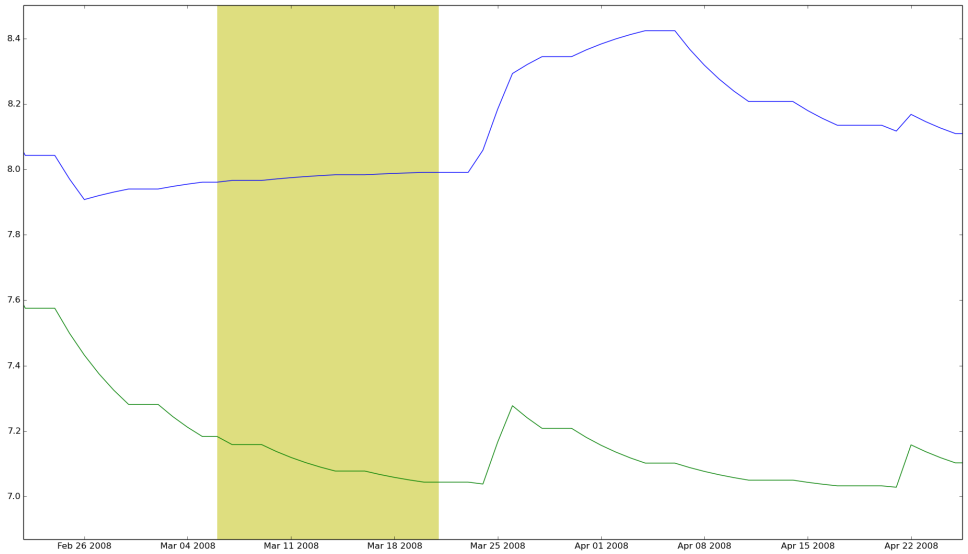

Figure 2: Window based correlation (Green line - Centre Retail Price, Blue Line - Average Retail Price)

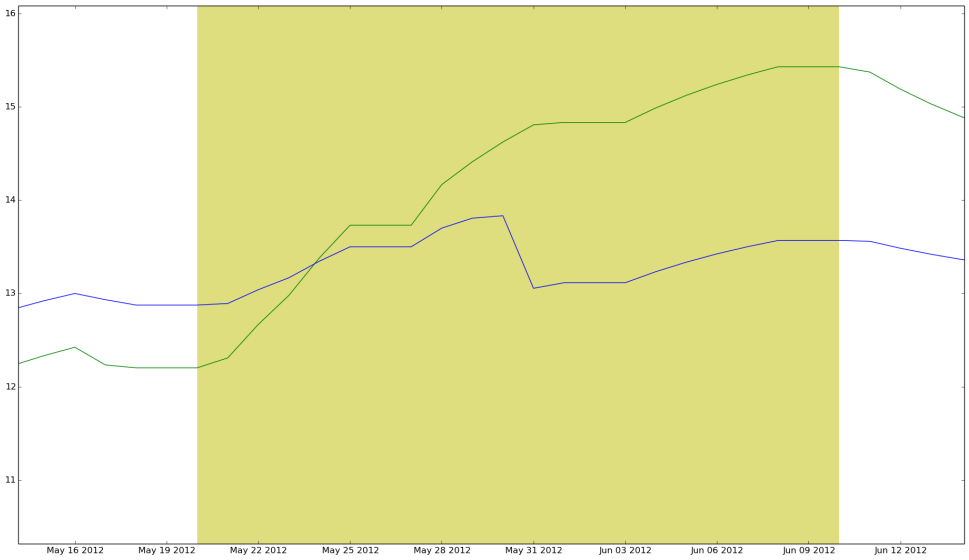

Figure 3: Slope Based Anomaly Detection (Green line - Centre Retail Price, Blue Line - Average Retail Price)

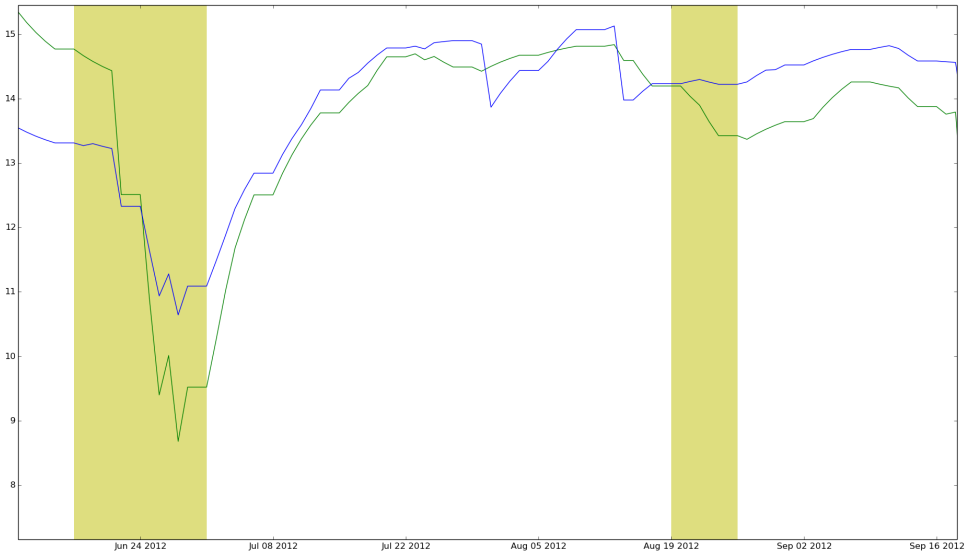

Figure 4: Slope Based Anomaly Detection (Green line - Centre Retail Price, Blue Line - Average Retail Price)

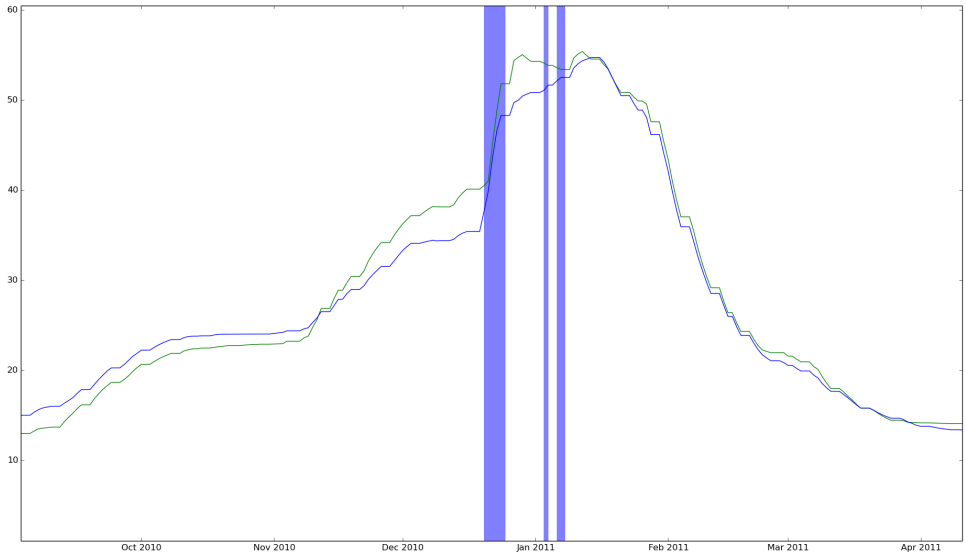

Figure 5: Slope Based Anomaly Detection (Green line - Centre Retail Price, Blue Line - Average Retail Price)

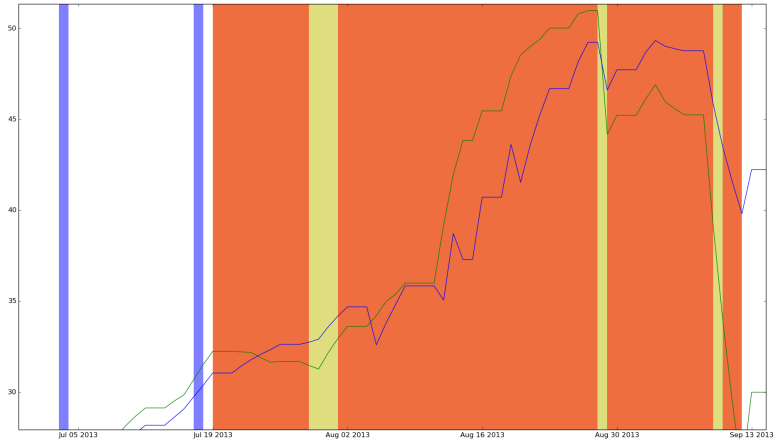

Figure 6: Vector Autoregressive (Green line - Centre Retail Price, Blue Line - Average Retail Price)

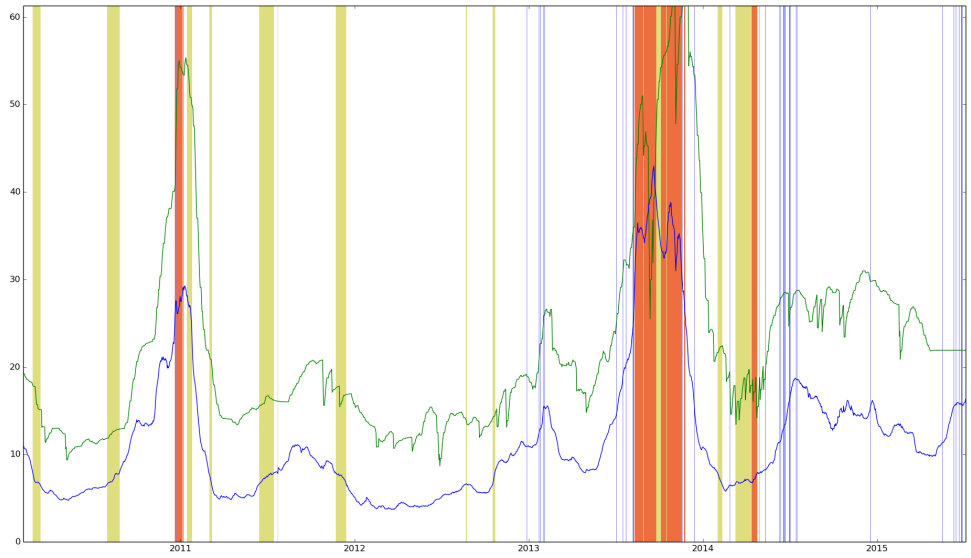

Figure 7: Graph Based Anomaly Detection (Green line - Retail Price, Blue Line - Wholesale Price)

1.1 Results

1.1.1 Matched Anomalies

Following table has few examples showing system reported anomalies and an article supporting it.

System Reported Tenure	News Articles Link	Analysis Type	Location
27-Dec-2010 to 29-Dec-2010	http://timesofindia.indiatimes.com/city/pune/Onion-prices-still-leave-consumers-teary-eyed/articleshow/7147525.cms	Retail vs Average	Mumbai
17-Oct-2013 to 27-Oct-2013	http://www.thehindu.com/business/Industry/monopoly-of-wholesale-trade-causing-onion-price-hike/article5264512.ece	Retail vs Average	Mumbai
15-Dec-2010 to 13-Jan-2011	http://articles.economictimes.indiatimes.com/2010-12-21/news/27586208_1_minimum-export-price-onion-prices-mep	Retail vs Arrival	Mumbai
17-Oct—2013 to 25-Nov-2013	http://www.dnaindia.com/mumbai/report-dna-exclusive-traders-not-farmers-making-the-most-of-soaring-onion-price-1909850	Retail vs Arrival	Mumbai
29-Jun-2014 to 06-July-2014	http://timesofindia.indiatimes.com/india/Retail-onion-prices-soar-to-double-of-wholesale-rates/articleshow/37490678.cms	Retail vs Arrival	Delhi
18-Nov-2013 to 24-Nov-2013	http://www.firstpost.com/politics/onion-tomato-price-hoardings-to-malign-party-cong-writes-to-ec-1238589.html	Retail vs Wholesale	Mumbai
21-Oct-2013 to 04-Nov-2013	http://www.dnaindia.com/mumbai/report-dna-exclusive-traders-not-farmers-making-the-most-of-soaring-onion-price-1909850	Retail vs Wholesale	Mumbai
27-Oct-2013 to 03-Nov-2013	http://www.thehindu.com/news/national/karnataka/are-farmers-benefiting-from-soaring-onion-prices/article5269250.ece	Retail vs Wholesale	Delhi
17-Oct-2013 to 24-Nov-2013	http://www.moneycontrol.com/news/economy/onion-prices-remain-high-at-rs-100kg-crisis-to-continue_976318.html	Wholesale vs Arrival	Mumbai
15-Dec-2010 to 12-Jan-2011	http://articles.economictimes.indiatimes.com/2010-12-21/news/27586208_1_minimum-export-price-onion-prices-mep	Wholesale vs Arrival	Mumbai
29-Jun-2014 to 05-July-2014	http://timesofindia.indiatimes.com/india/Retail-onion-prices-soar-to-double-of-wholesale-rates/articleshow/37490678.cms	Wholesale vs Arrival	Delhi

Table 2: Few Examples

Explaination of all the cases listed in table are as following:

- 27-Dec-2010 to 29-Dec-2010 : According to our hypothesis 4, price trends at different centers should behave similar. But, here retail price of onion in Mumbai took a sharp rise then faced a downfall which was not seen being followed by Delhi. Instead retail prices at Delhi continued to grow. There were multiple news articles for the same tenure which claimed traders nexus as reason for anomaly. One of the article link is given in table. (See Figure 8)

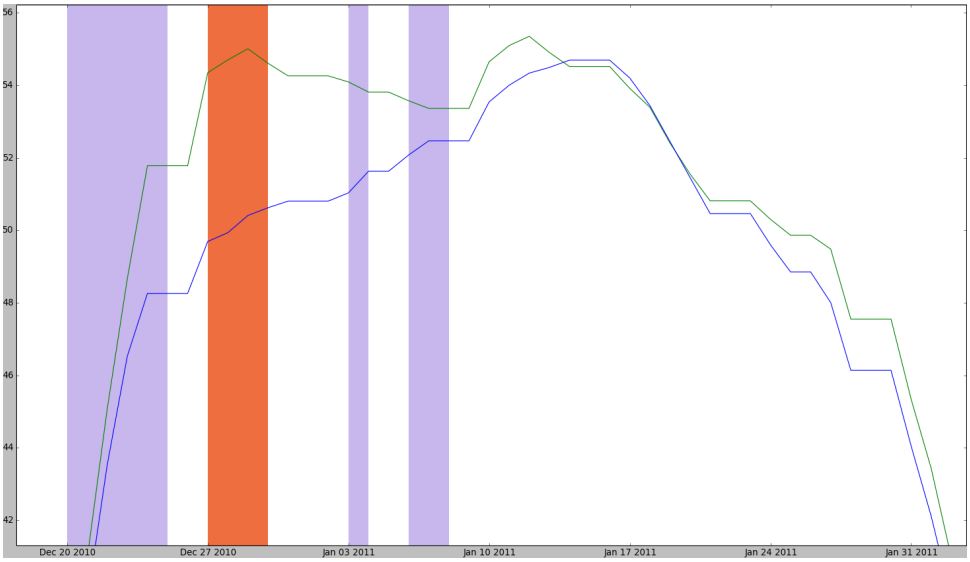

Figure 8: Case: 27-Dec-2010 to 29-Dec-2010 (Green line - Centre Retail Price, Blue Line - Average Retail Price)

Similar is observed for 17-Oct-2013 to 27-Oct-2013. (See Figure 9)

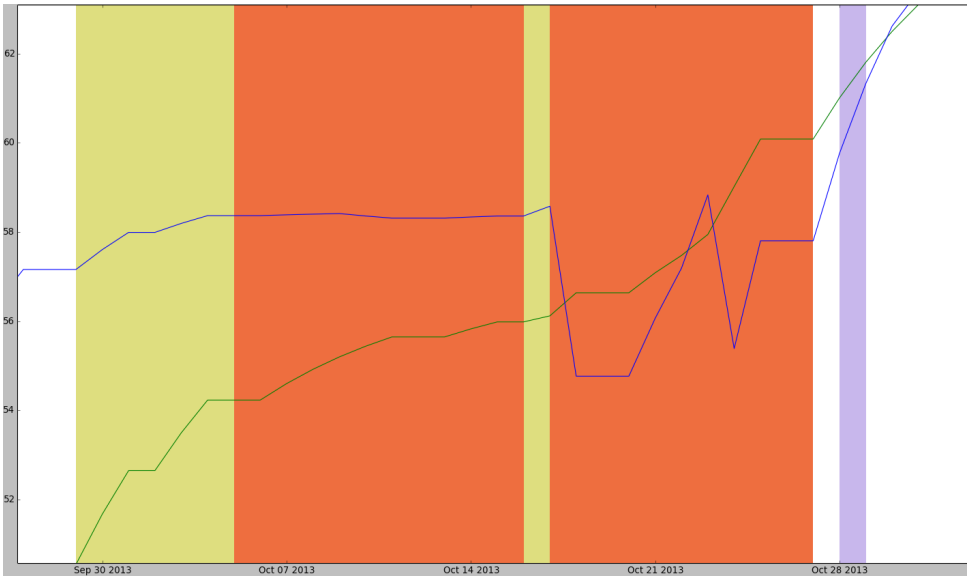

Figure 9: Case: 17-Oct-2013 to 27-Oct-2013 (Green line - Centre Retail Price, Blue Line - Average Retail Price)

- 15-Dec-2010 to 13-Jan-2011 : There was a decrease in the arrival of onion in Mumbai at the start of December which resulted in the increase of retail price. Later arrival seemed nearly constant or increasing but prices continued to grow high. The arrival also increased when the prices were very high which could be the arrival of hoarded stock in market for profiteering.

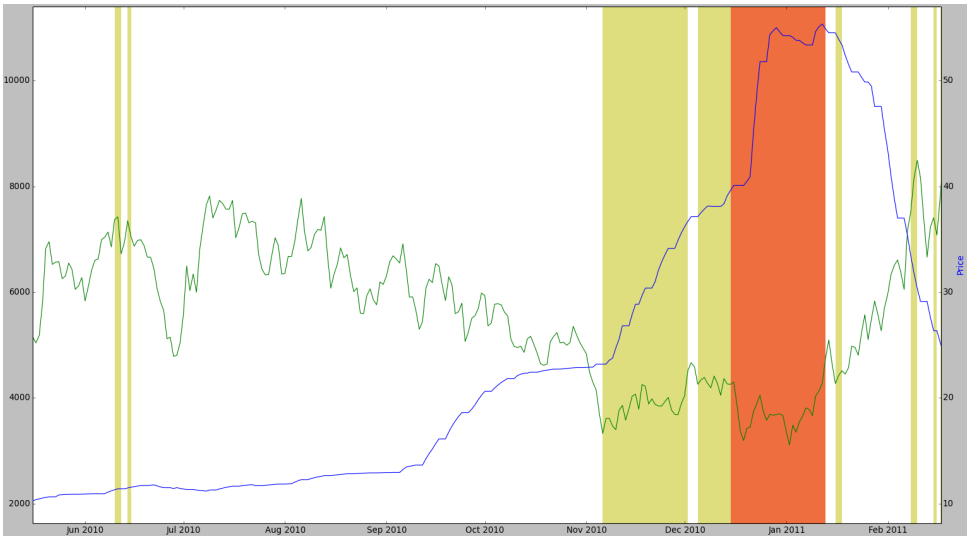

Figure 10: Case: 15-Dec-2010 to 13-Jan-2011 (Green line - Arrival Data of Onion, Blue Line - Retail Price)

Similar is observed for 17-Oct-2013 to 25-Nov-2013. (See Figure 11)

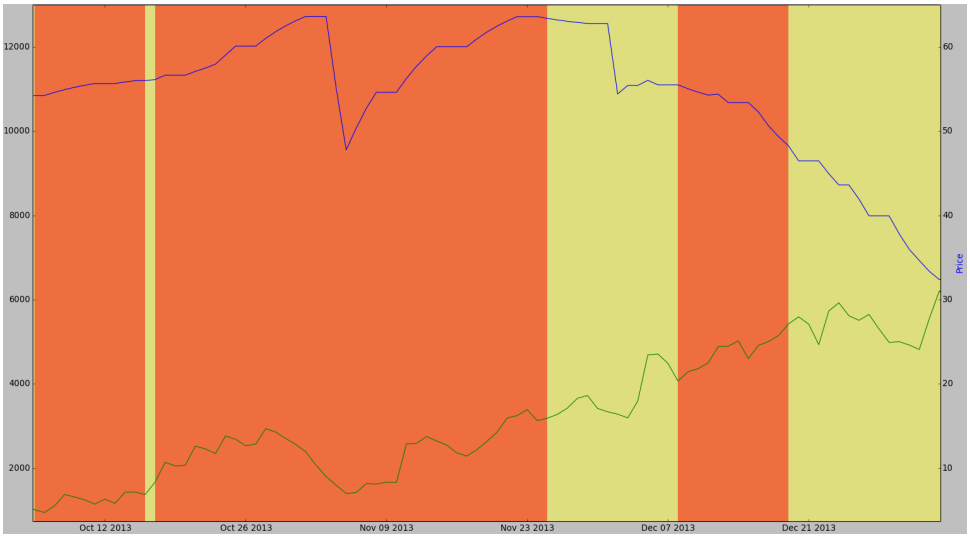

Figure 11: Case: 17-Oct-2013 to 25-Nov-2013 (Green line - Arrival Data of Onion, Blue Line - Retail Price)

Similar is observed for 29-Jun-2014 to 06-July-2014 in Delhi. (See Figure 12)

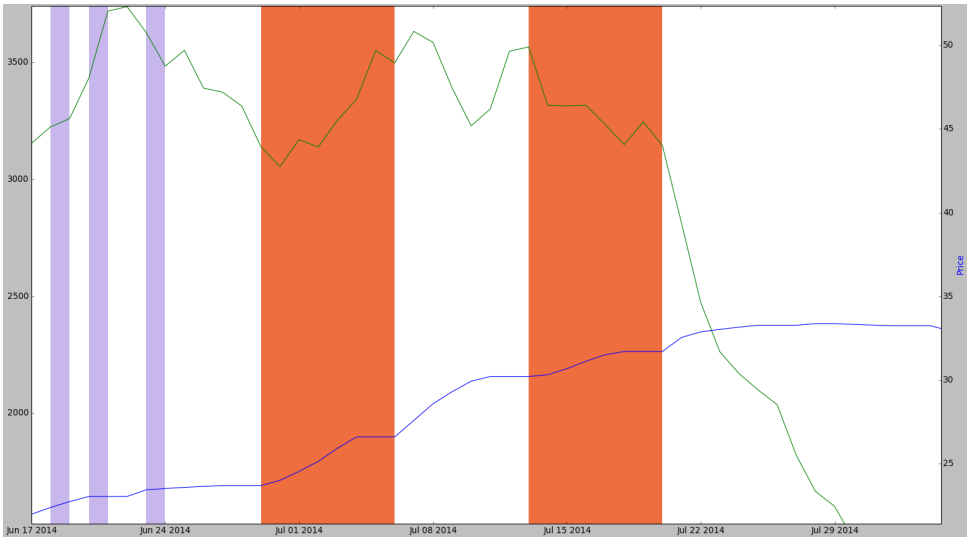

Figure 12: Case: 29-Jun-2014 to 06-July-2014 (Green line - Arrival Data of Onion, Blue Line - Retail Price)

- 18-Nov-2013 to 24-Nov-2013 : Retail prices are decided by wholesale price. But here in Mumbai, retail price continued to remain high despite of decrease in the wholesale price. (See Figure 13)

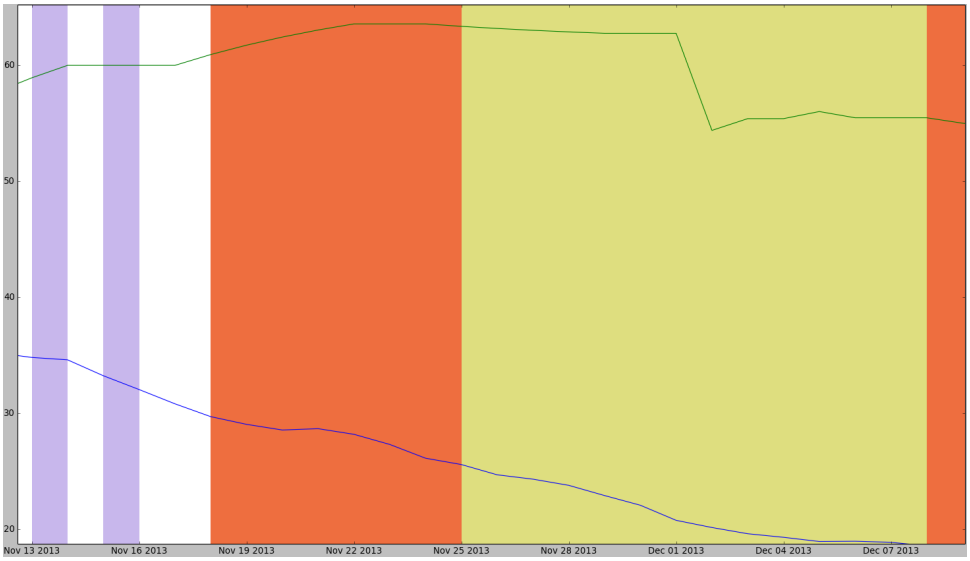

Figure 13: Case: 18-Nov-2013 to 24-Nov-2013 (Green line - Retail Price, Blue Line - Wholesale Price)

Similar is observed for 21-Oct-2013 to 04-Nov-2013. (See Figure 14)

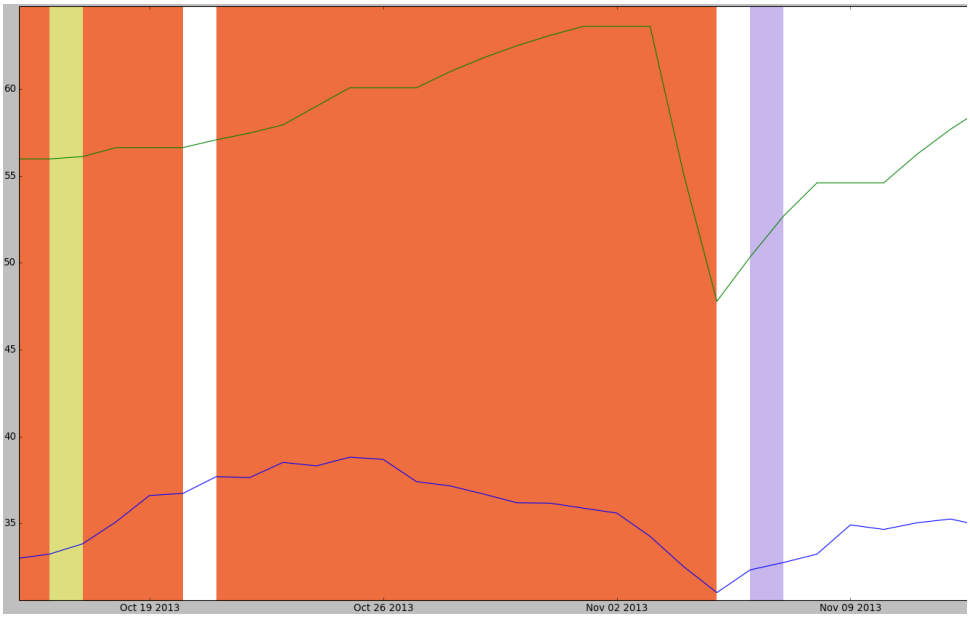

Figure 14: Case: 21-Oct-2013 to 04-Nov-2013 (Green line - Retail Price, Blue Line - Wholesale Price)

Similar is observed for 27-Oct-2013 to 03-Nov-2013 in Delhi. (See Figure 15)

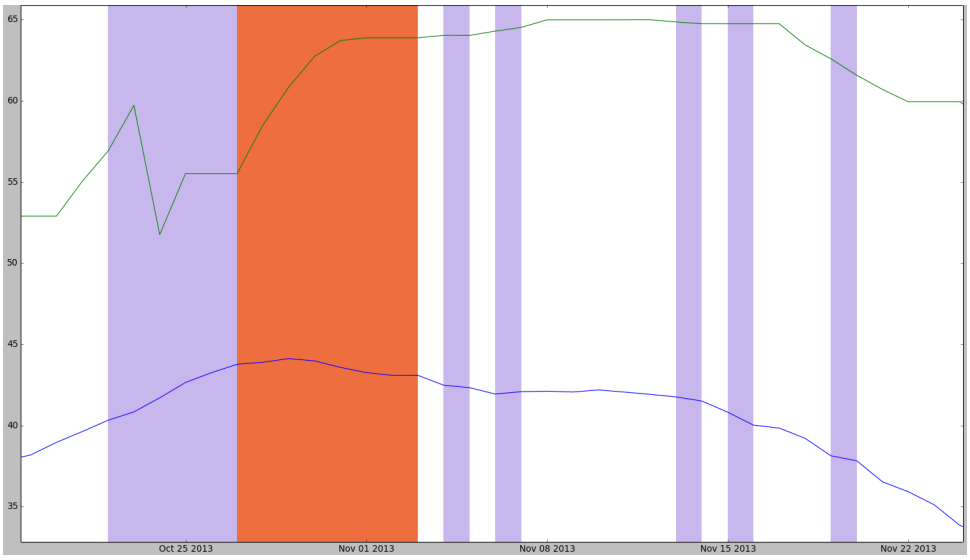

Figure 15: Case: 27-Oct-2013 to 03-Nov-2013 (Green line - Retail Price, Blue Line - Wholesale Price)

- 17-Oct-2013 to 24-Nov-2013 : Market observed increase in the arrival on increase of wholesale in Mumbai. The supply crunch could be man-made which resulted in increase in wholesale price and then to take advantage of increased prices, stocks were released in market. (See Figure 16)

Figure 16: Case : 17-Oct-2013 to 24-Nov-2013 (Green line - Arrival Data of Onion, Blue Line - Wholesale Price)

Similar is observed for 15-Dec-2010 to 12-Jan-2011. (See Figure 17)

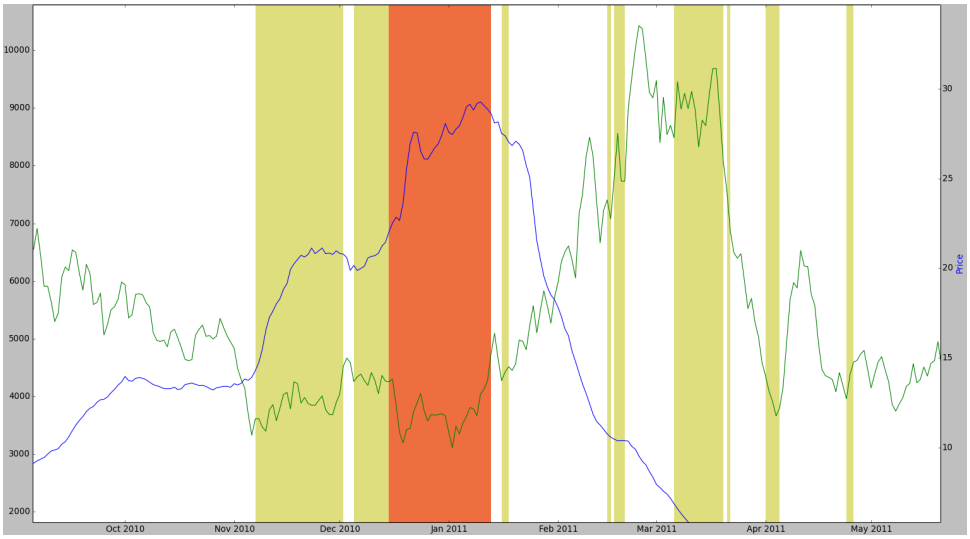

Figure 17: Case : 15-Dec-2010 to 12-Jan-2011 (Green line - Arrival Data of Onion, Blue Line - Wholesale Price)

Similar is observed for 29-Jun-2014 to 05-July-2014 in Delhi. (See Figure 18)

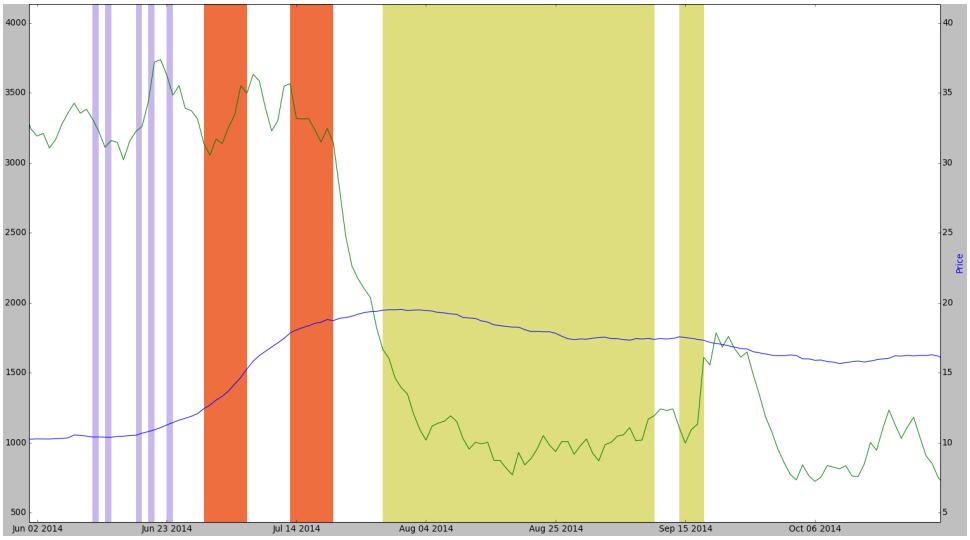

Figure 18: Case : 29-Jun-2014 to 05-July-2014 (Green line - Arrival Data of Onion, Blue Line - Wholesale Price)

1.1.2 Local News Article Matched Anomaly

Few of the analysis which were local to center could not be matched with national news articles, but on digging more in regional news article, we could justify the anomaly. One of such case is the anomaly reported on 7th and 8th January 2013, in Delhi, for which news was reported in Jagran local news paper on 28th December 2012 which says due to fog there was disruption in the supply of onions. Despite of the speculation on low arrival of onion we observed considerable hike in arrival (which could be hoarded onion stocks brought into market) to earn better profits to take advantage of increased price of onion. Also, we have observed 2 news articles suspecting traders' nexus as the reason for the increased onion prices.

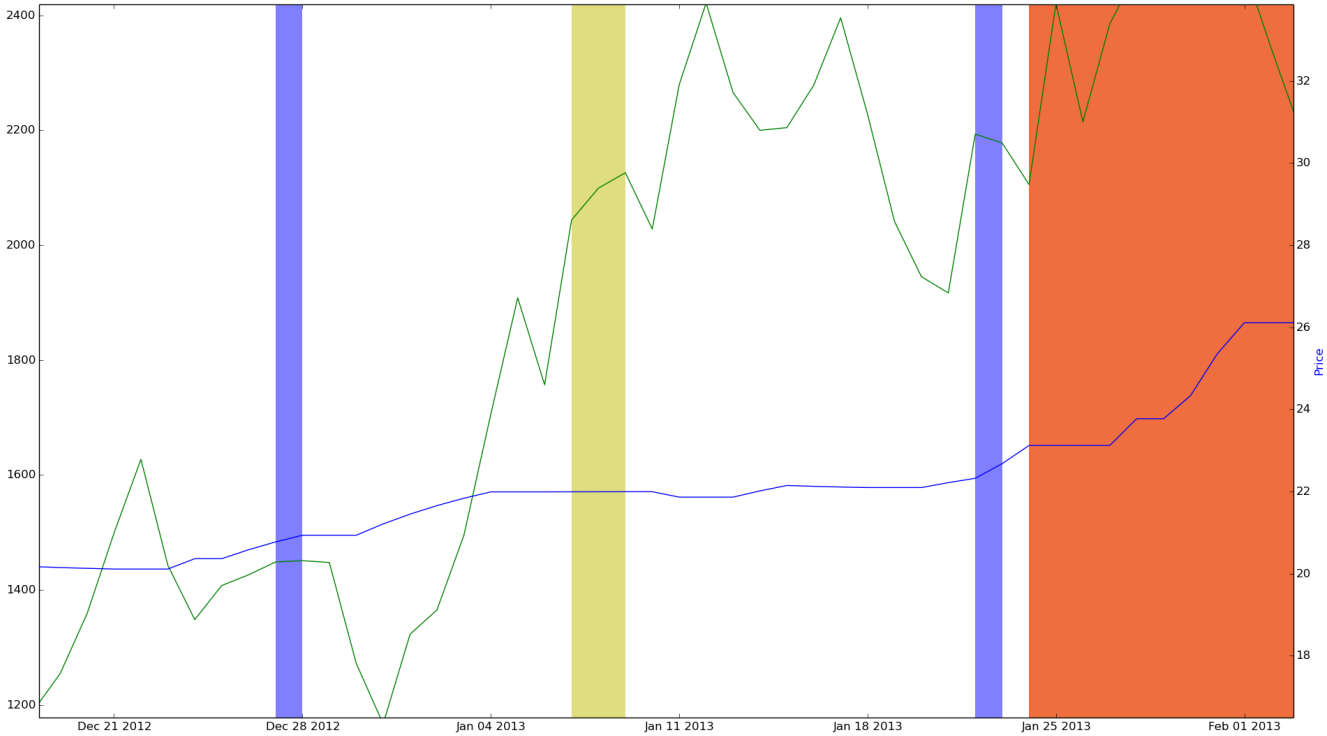

Figure 19: System Result (Green line - Arrival Data of Onion, Blue Line - Retail Price)

News Article stated the following,

नई दिल्ली [सुरेंद्र प्रसाद सिंह] प्याज एक बार फिर आंसू निकालने को तैयार है। ठंड बढ़ने से जहां प्याज की मांग बढ़ी है, वहीं आपूर्ति कम होने से प्याज की कीमतें साल के उच्चतम स्तर पर पहुंच गई हैं। उत्पादक और उपभोक्ता मंडियों के मूल्य में भारी अंतर तो है ही, थोक और खुदरा कीमतों की खाई भी बढ़ गई है। कोहरे की वजह से महाराष्ट्र की प्याज की सप्लाई लाइन टूट गई है।

Figure 20: Jagran News paper article

1.1.3 Reported but Not Matched

Sometimes anomalies are seen even before the news articles actually report them. One of such case is seen in the following figure :

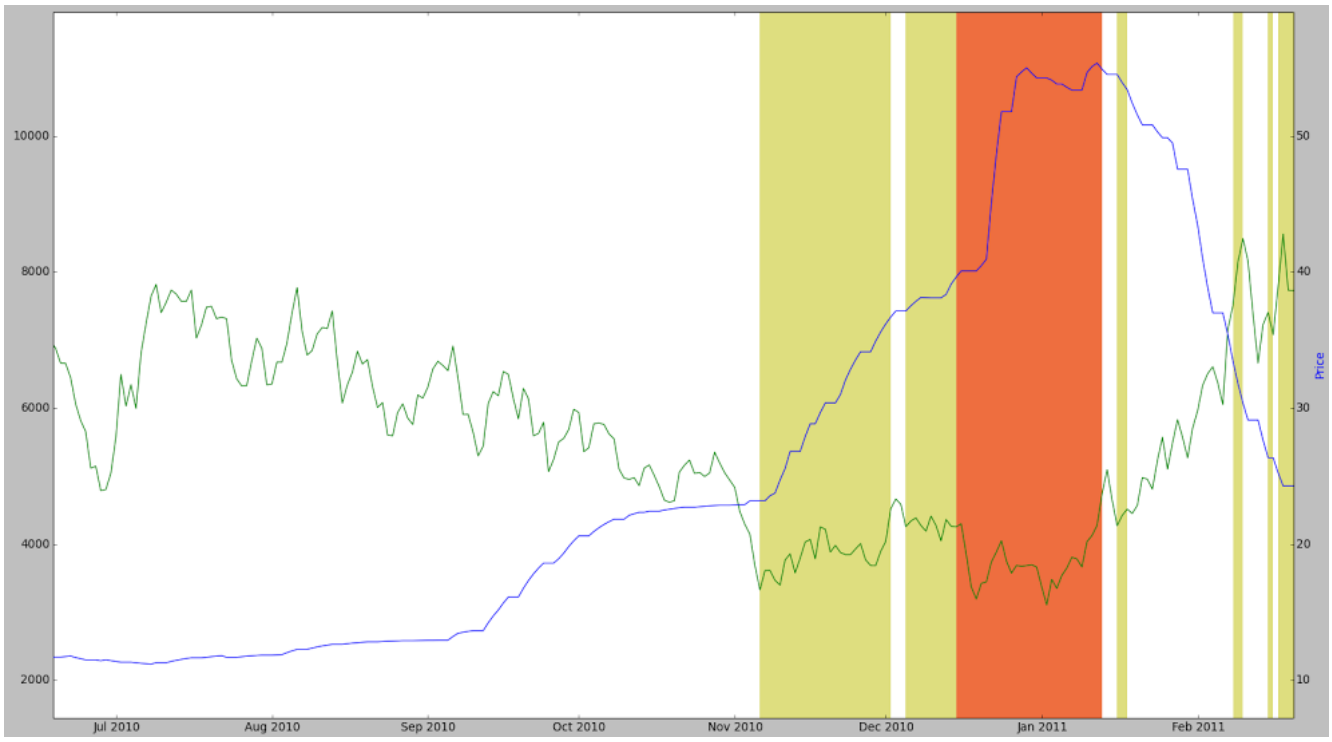

Figure 21: System Result (Green line - Arrival Data of Onion, Blue Line - Retail Price)

Here, the anomalies have started being seen in the mid of November. But, the news reported incidents in mid of December. Since arrival was increasing and still retail price was increasing hence it was reported which is quite normal.

1.1.4 Articles Missed

In some cases, onion is seen in news because of unseasonal rainfall or low production etc. These cases are not anomalous and rise in prices of onion are expected behaviour. Following is one case, where violet lines indicate news reported on unseasonal rainfall resulting in low production:

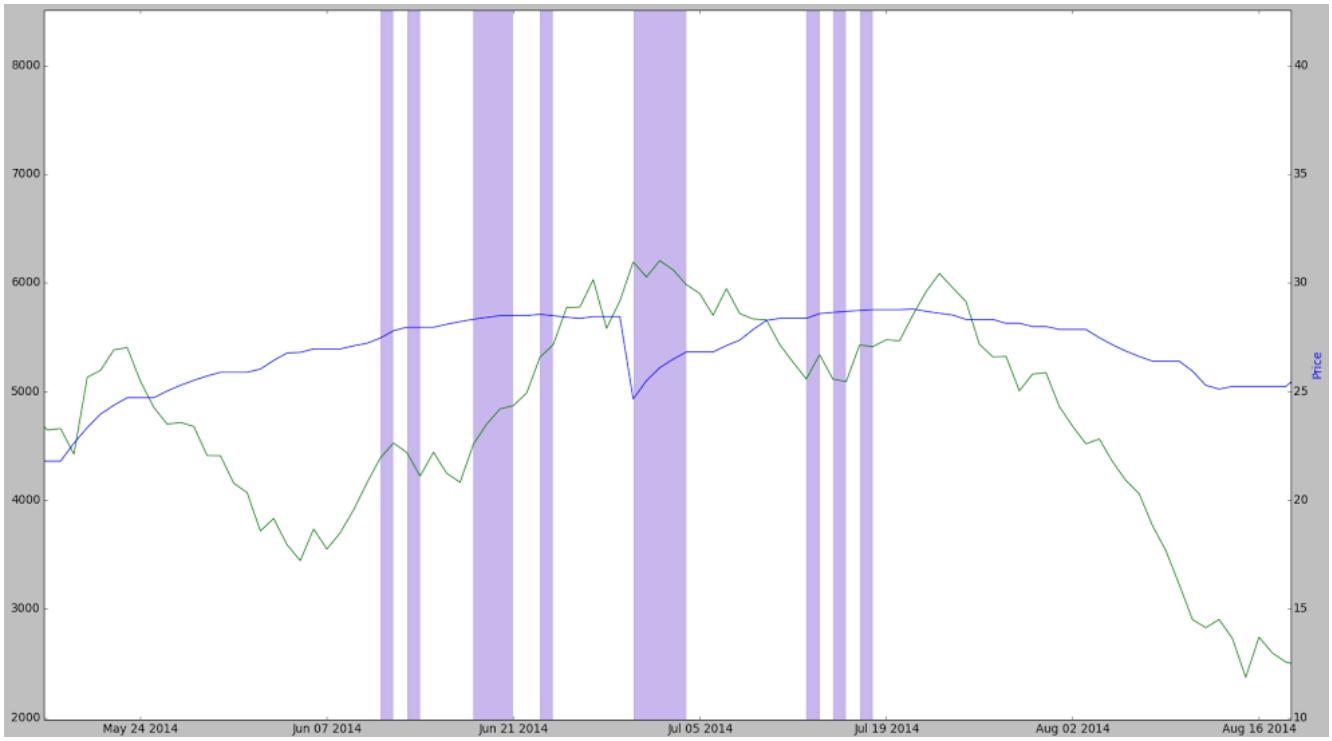

Figure 22: System Result (Green line - Arrival Data of Onion, Blue Line - Retail Price)

Here, system did not report any anomaly because the arrival has lowered which has lead to the increase in prices which is normal behaviour of system.