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Trend and Seasonal Analysis for Dwelling Fire Totals in Scotland over the seven-year period April 2009 to March 2016

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Summary

- Over the past seven years there have been declines in Accidental Dwelling fires, but from about mid-2013 onwards that decline has slowed and to some extent reversed. Deliberate dwelling fires show a much-steeper decline over the same period, but with a similar tailing off of the reduction since mid-2013.
- Accidental Dwelling Fires peak around December each year and are in general at their lowest in the summer and early autumn months from June to September.
- On average the number of accidental dwelling fires in December is 16% higher than the overall mean monthly total. In summer the number of accidental dwelling fires is about 7% lower than the overall mean monthly total.
- Whilst there are distinct seasonal peaks and troughs in the occurrence of accidental dwelling fires, deliberate dwelling fires show an entirely different pattern. Accidental dwelling fires peak in winter and are at their lowest in summer each year. For deliberate dwelling fires, the median of the winter period totals is lower than the for the other three seasons.
- Seasonal variations in accidental dwelling fires do not have a direct or simple relationship to the number of fatalities which result. If the likelihood of an accidental dwelling fire resulting in fatalities is equally spread throughout the year we would expect to see the same pattern in the totals for accidental dwelling fire fatalities by month, but we do not.
- Whilst accidental dwelling fires peak in December and are at their lowest in the summer months, the number of fatalities per incident is consistently a little lower than would be expected in December and higher than would be expected in summer if fatality rates were constant throughout all months.
- There are clearly other factors than seasonality involved in variations between the number of accidental dwelling fires and the number of fire fatalities which result from those fires. In due course we need to take these into account, by modelling for example the type and severity of the incident, and the causal factors that resulted in a fatality.

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Overall Trends

Over the past seven years there have been declines in Accidental Dwelling fires, but from about mid-2013 onwards that decline has slowed and to some extent reversed:

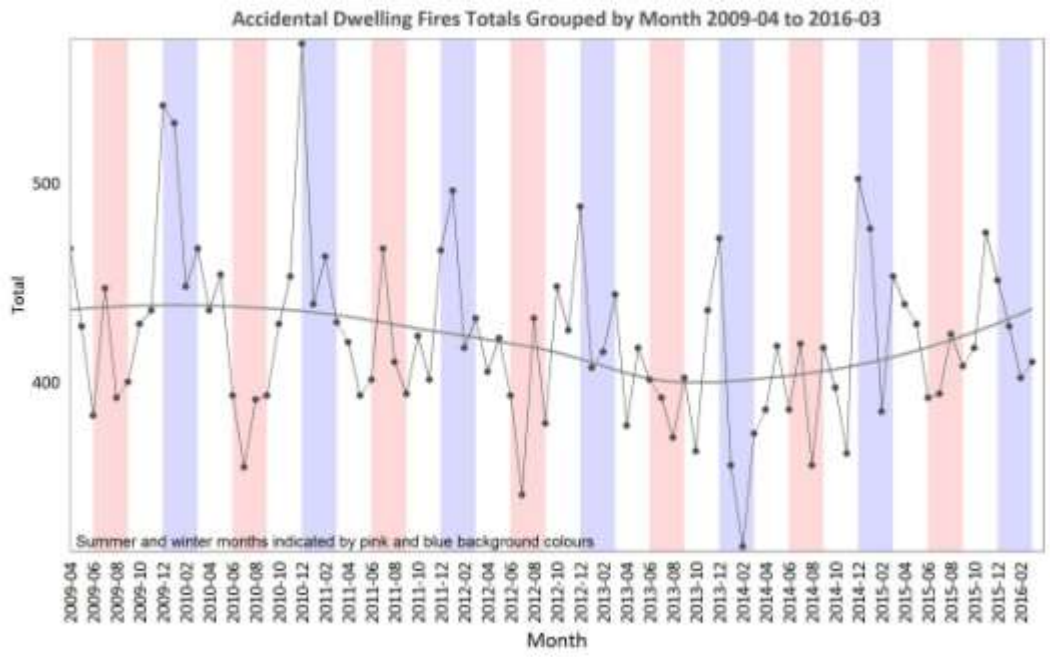

Figure 1: Monthly totals for accidental dwelling fires

The considerable month-to-month variability shown in Figure 1 above is typical of semi-random events with trend and seasonal components. Using specialist software these can be separated to show the trend, seasonal and random components involved:

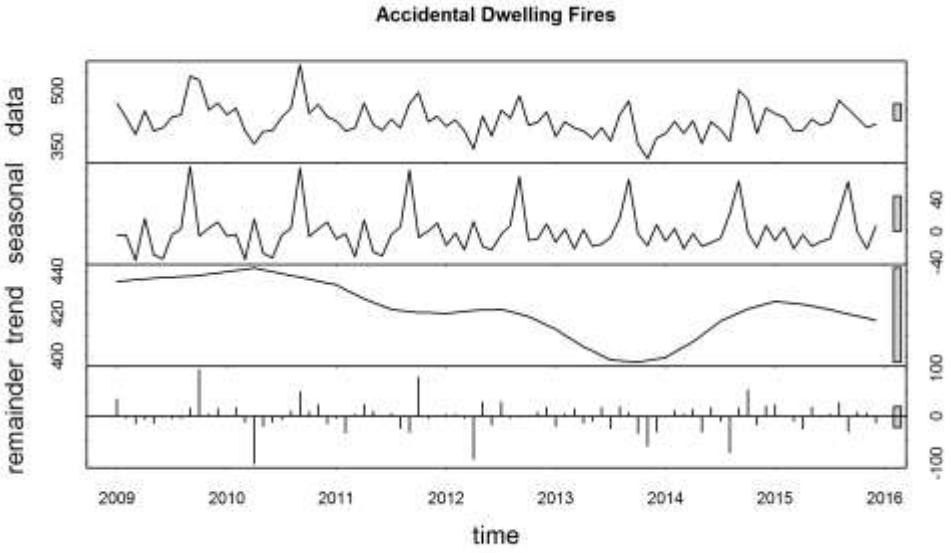

Figure 2: Accidental dwelling fire seasonal decomposition

The de-seasonalised trend line in Figure 2 shows some cyclic variability, with a cyclic upturn around mid-2013 onwards to the end of the 2014-15 financial year.

Deliberate dwelling fires show a much-steeper decline over the same period, tailing off over the past eighteen months.

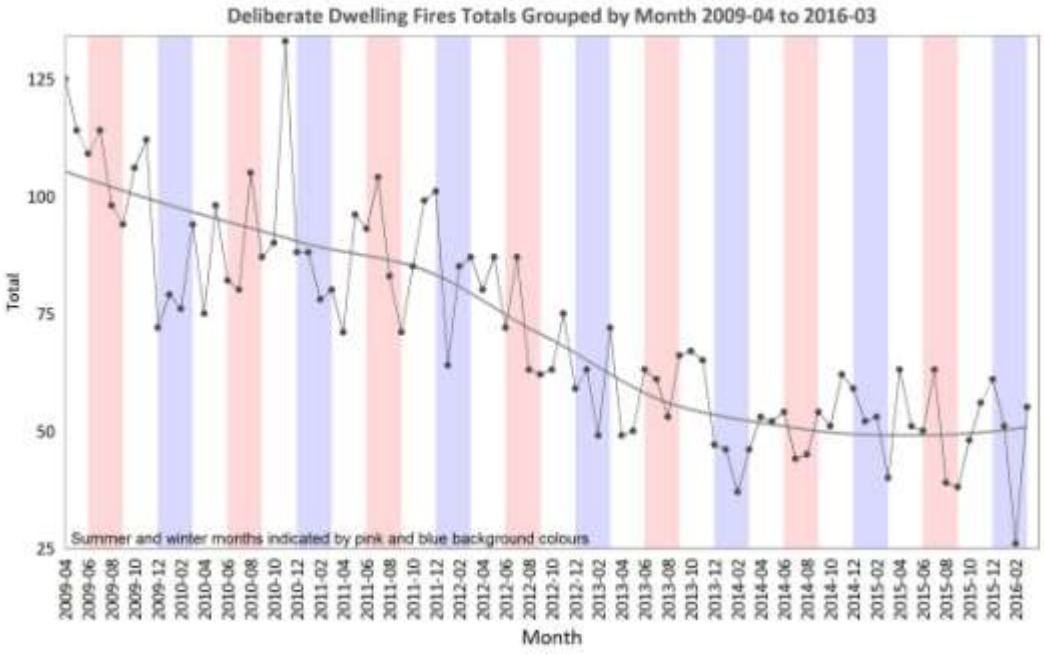

Figure 3: Monthly totals for deliberate dwelling fires

The de-seasonalised trend line for deliberate dwelling fires is more linear but still shows some evidence of cyclic variability, with a flattening of the trend from mid-2013 onwards:

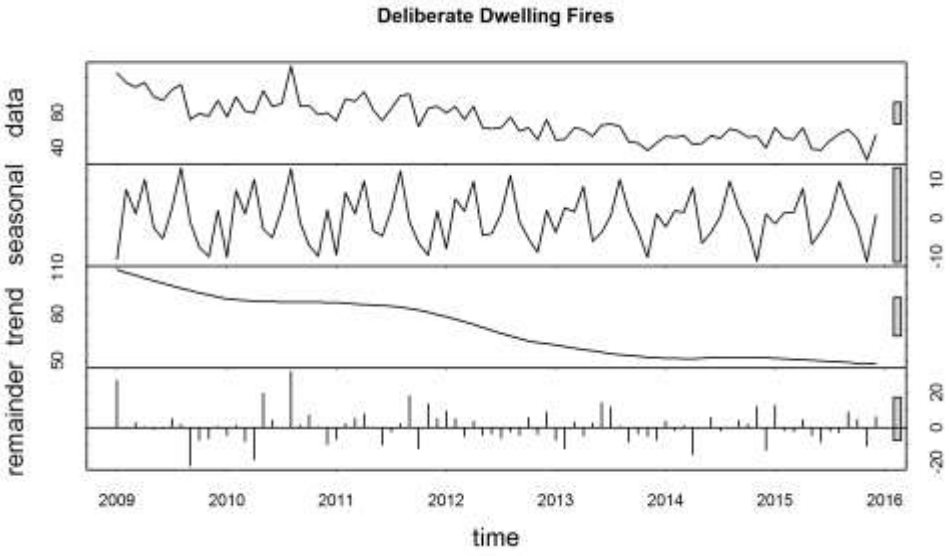

Figure 4: Deliberate dwelling fire seasonal decomposition

Working with data where there is such seasonal variability one could ask whether the increases in accidental dwelling fires in particular indicated by the trend lines could be accounted for in some way by changes in seasonality for instance, as recent winters have been both warmer and wetter than average. In answer to this we have also modelled the monthly totals for accidental dwelling fires as simple heat-maps, where the darker cells show larger totals:

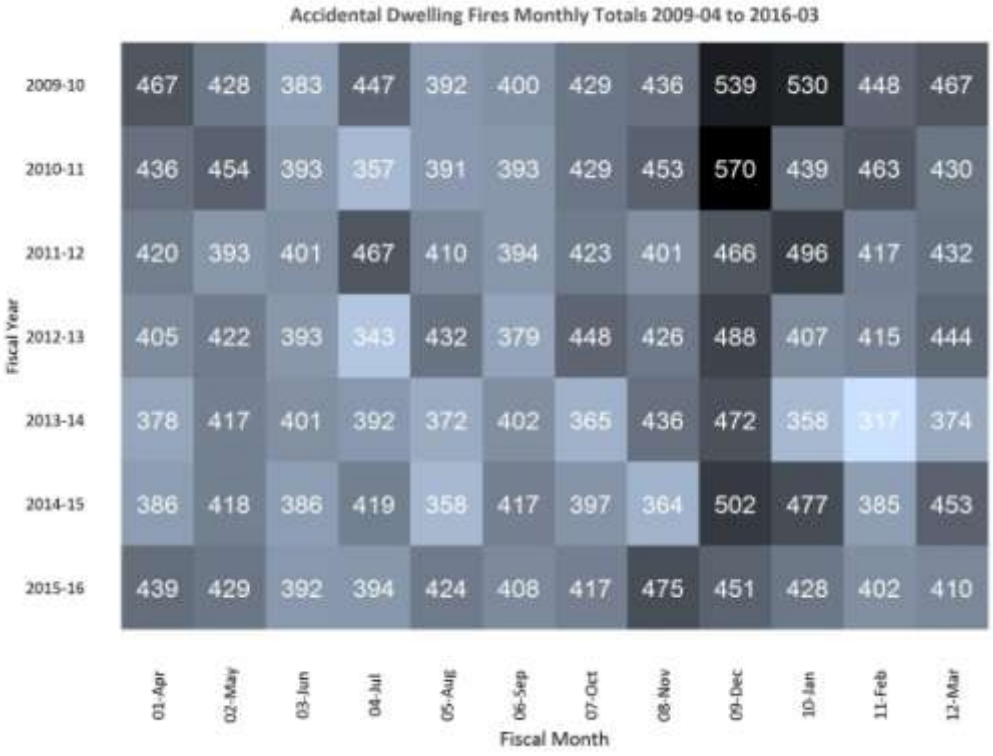

Figure 5: Accidental dwelling fires Heat-map

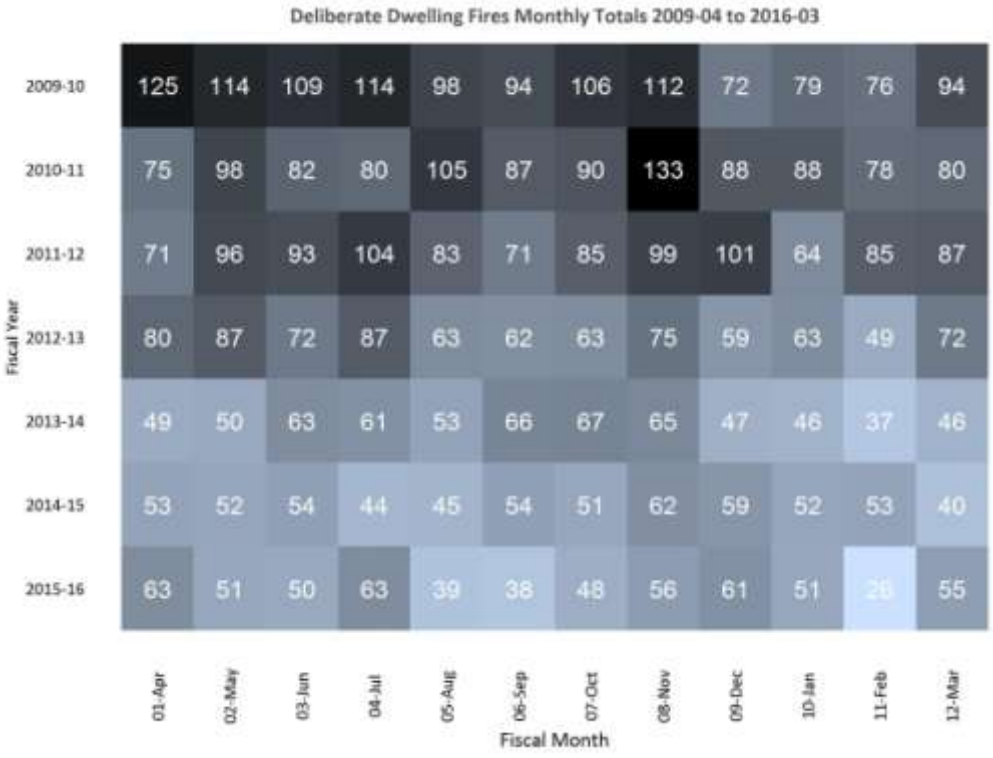

Figure 6: Deliberate dwelling fires Heat-map

The brighter colours of the accidental dwelling fire heat-map cells for January to March 2013-14 show the unusually-low totals for dwelling fires over that period, with February standing out (the lightest cell on the lower right of both charts). This coincides with the severe wet weather that winter, though it is difficult to envisage any form of link between exceptionally wet weather and reductions in dwelling fires. There are no similar patterns noted for the period of exceptionally wet weather that occurred in late 2015.

Seasonal Monthly Variations in Dwelling Fires

To some extent self-evidently fires in the home occur more frequently in the colder weather in winter than in the warmer summer months. There are distinct seasonal peaks and troughs in the occurrence of accidental dwelling fires, but deliberate dwelling fires follow an entirely different pattern.

Accidental Dwelling Fires

Accidental Dwelling Fires peak around December each year and are in general at their lowest in the summer and early autumn months of June to September, though there are some exceptional years as shown by the lower outlier dots on Figure 7 below

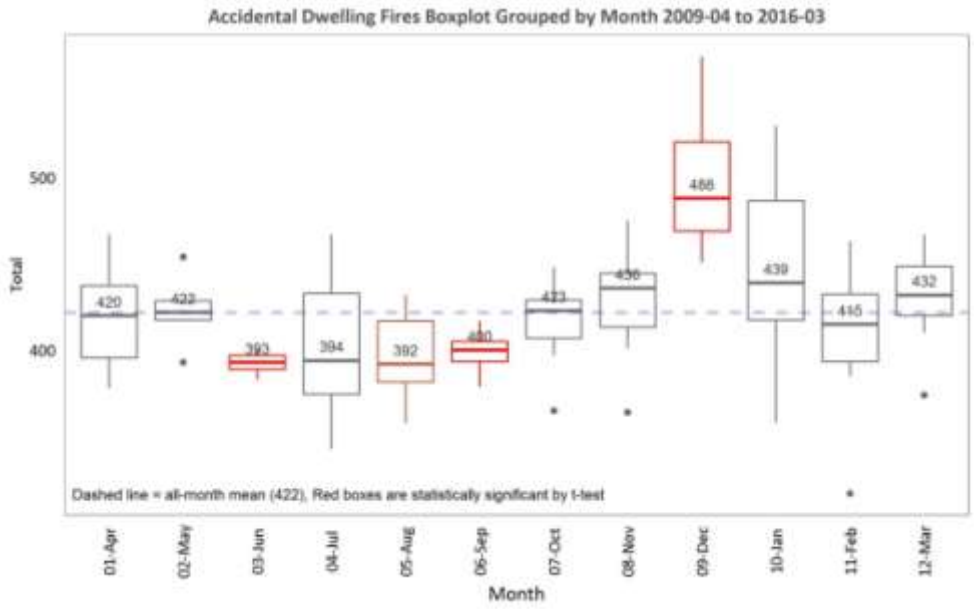

Figure 7: Accidental dwelling fires boxplot

In the accidental dwelling fires boxplot[1] above, the totals for June, August, September and December test as being significantly different to the mean value (within the 1% range for June, September and December, and the 5% range for August).

The month range values show interesting variability, with ADF totals for July varying much more widely than the two months on either side. ADF totals in January also show considerable variability, much more so than in the peak month of December.

Although median and mean values are different measures of central tendency, the mean and median values for accidental dwelling fires are very closely related and accordingly can be compared almost interchangeably. The December median value of 488 accidental dwelling fires is 66 above the overall mean monthly value of 422 ADFs per month, an increase of 16% on the monthly average.

The months with the minimum median values (June and August) are 7% below the monthly average for the period.

[1] *Boxplots show the range and variability of the totals for each month. The vertical lines outside the boxes indicate normal maximum and minimum ranges, with dots representing outlier values. The shoulders of the boxes indicate the 25th and 75th percentile ranges, and the horizontal line within the box indicates the median value (the 50th percentile or middle value, which has been annotated on the chart above for clarity). The mean monthly total for the period 2009-04 to 2016-03 is shown by the dashed line on the chart.*

A four-season view of the data shows that accidental dwelling fire totals in general peak in the winter months each year (December to February) and are at their lowest in summer (June to August), though the range of dwelling fire totals in winter each year is very wide.

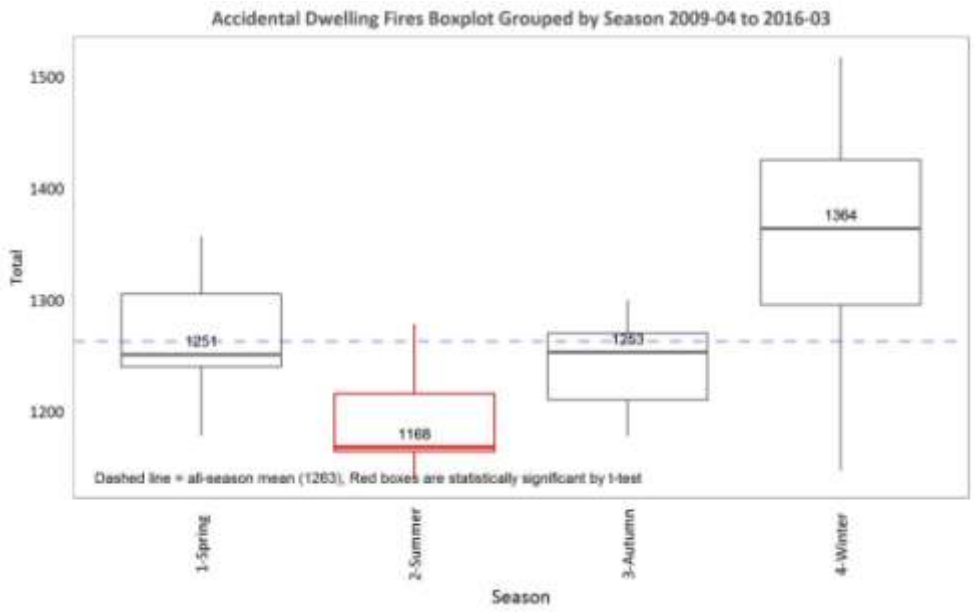

Figure 8: Seasonal boxplot of accidental dwelling fire totals

The summer month mean value tests as being significantly lower than the overall seasonal mean value of 1263 at the 5% level. The summer median, 1168, is 7.5% lower than the overall mean value of 1263 accidental dwelling fires per season.

Deliberate Dwelling Fires

Deliberate dwelling fires are those judged to have been started as a result of a deliberate or wanton act. Whatever the motivations of the person or persons concerned, the pattern of deliberate dwelling fires shows none of the seasonal factors associated with accidental dwelling fires.

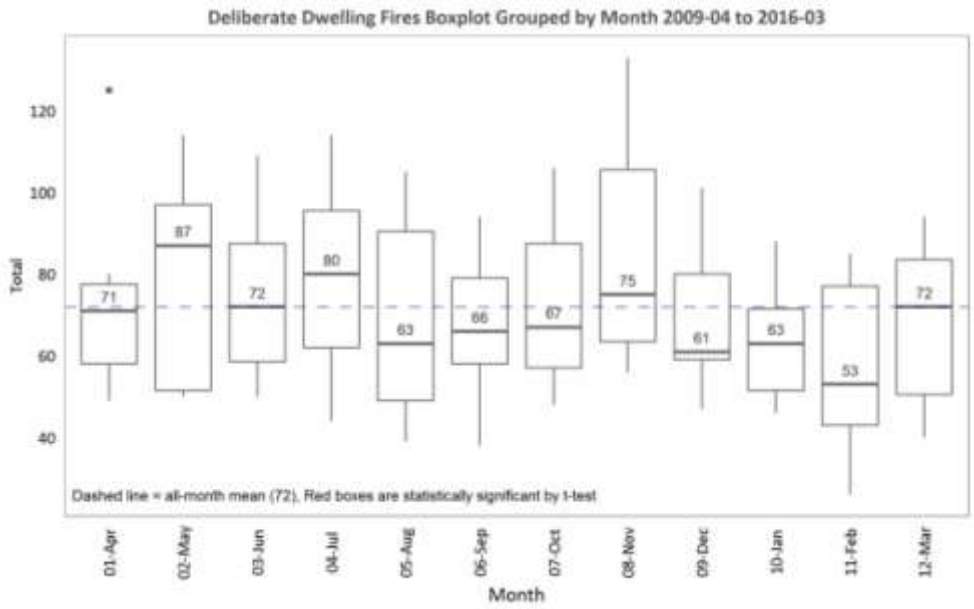

Figure 9: Deliberate dwelling fires boxplot

None of the monthly means for deliberate dwelling fires are significantly different to the overall monthly mean of 72 per month, though the month of November shows the widest overall variation and the highest overall maximum value.

A four-season view of the data shows that unlike accidental dwelling fire totals, those for deliberate dwelling fires do not peak in the winter months at all. The median for the winter period is lower than the medians for the other seasons, though none of the means are significantly different to the overall seasonal mean of 212.

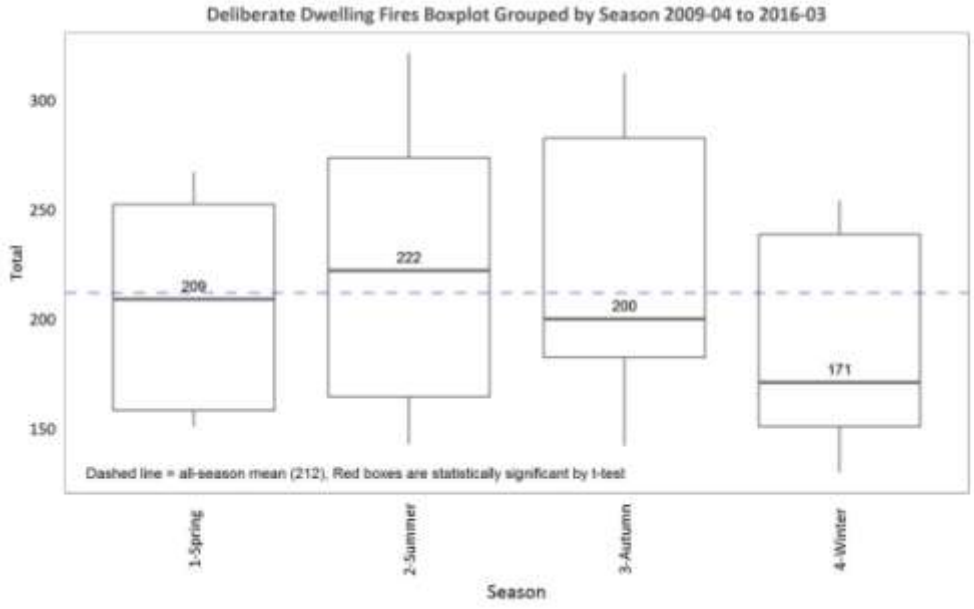

Figure 10: Seasonal boxplot for deliberate dwelling fires

Taking the individual monthly totals for deliberate dwelling fires and plotting these as a bar chart by month and year shows diminishing differences from the mean value in recent years, with a peak reduction in February in many years:

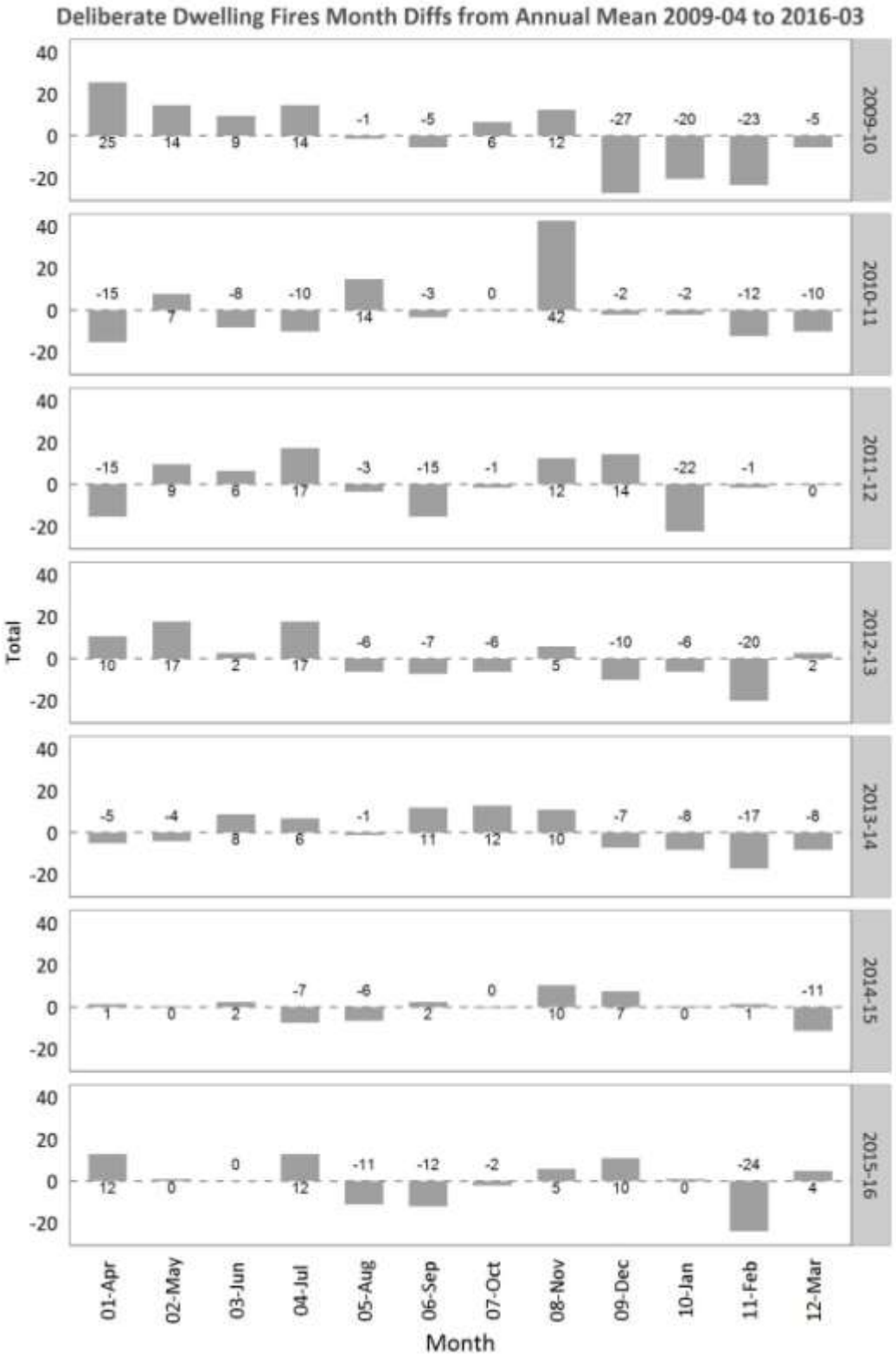

Figure 11: Differences between annual monthly mean and individual monthly totals for deliberate dwelling fires

This suggests that the number of deliberate dwelling fires is tending towards a floor value of some kind which is not varying strongly from month to month at present, give or take random fluctuations.

Accidental Dwelling Fire Fatalities

In this section we show that the seasonal variations in accidental dwelling fires noted previously do not have a direct or simple relationship with the number of fatalities which result.

The monthly totals for accidental dwelling fire fatalities from April 2009 to March 2016 are shown below:

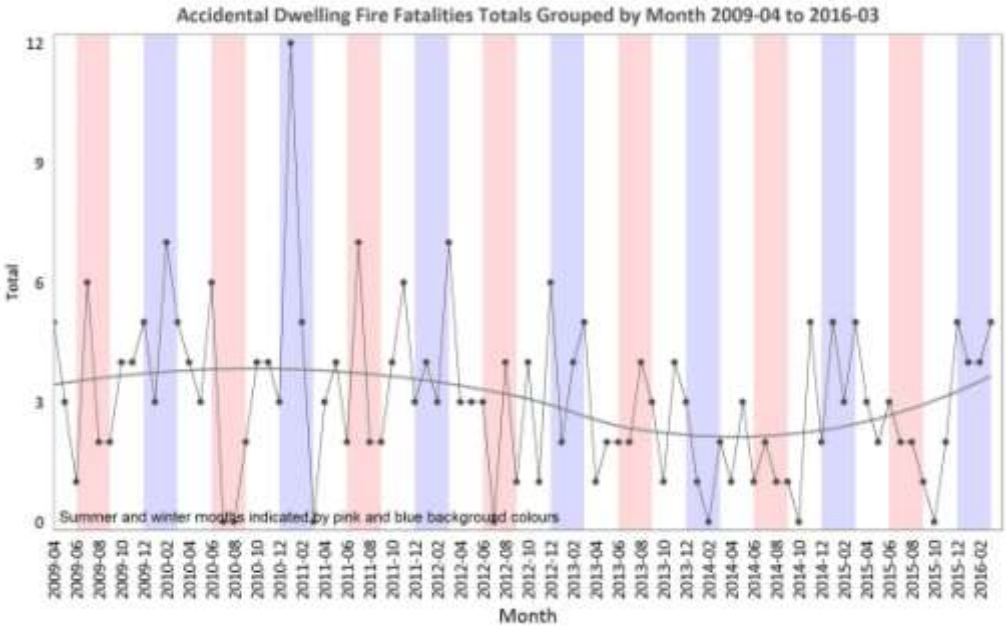

Figure 12: Accidental dwelling fire fatalities by month

If we assume for the moment that increases or decreases in the number of incidents results in increases or decreases in fatalities the trend line in the Figure 11 may only be showing us changes associated with the number of accidental dwelling fires, which we know have increasedfrom mid-2013 onwards. We can instead show the rate of accidental dwelling fire fatalities per thousand accidental dwelling fire incidents:

The increase in fatalities is shown more starkly on the trend component of the seasonal decomposition plot below:

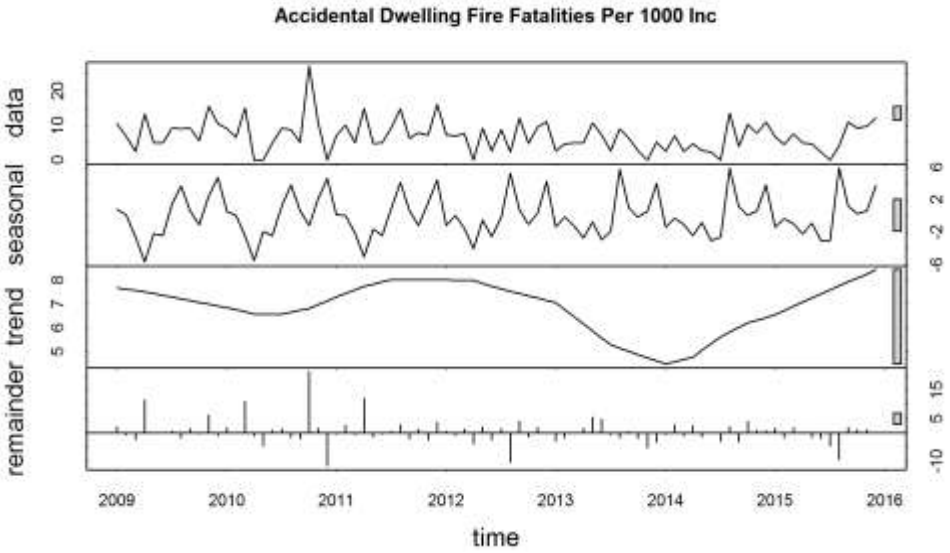

Figure 13: Seasonal decomposition of accidental dwelling fire fatalities per thousand incidents

We noted earlier that accidental dwelling fires peak in December and are at their lowest in the summer months. If the likelihood of an accidental dwelling fire resulting in fatalities is equally spread throughout the year we would expect to see the same pattern in the totals for accidental dwelling fire fatalities by month, but we do not:

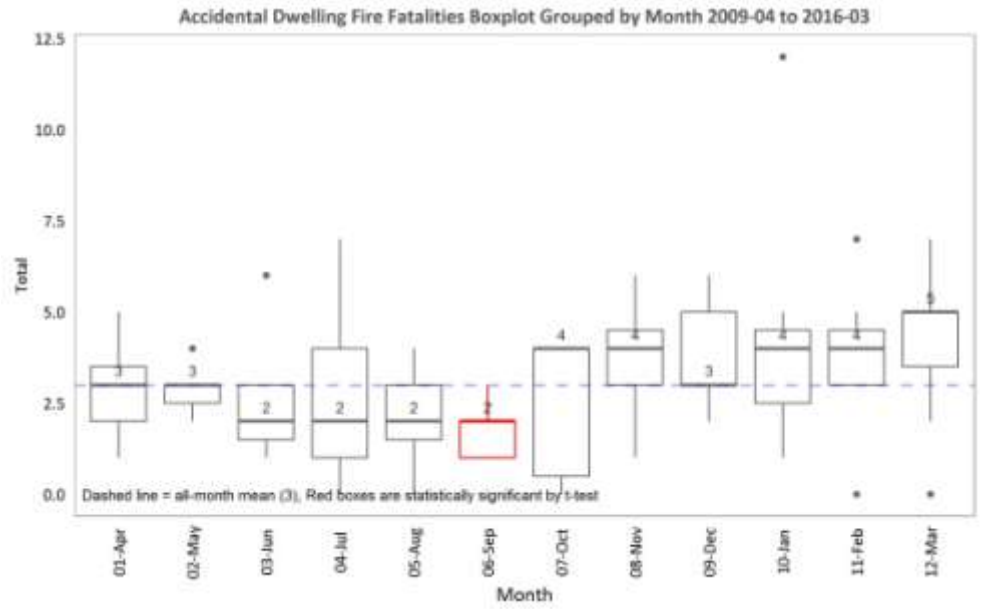

Figure 14: Accidental dwelling fire fatalities boxplot

Further evidence that there are unexpected seasonal differences in the number of fatalities against the number of dwelling fires can be obtained by plotting the normalised rate of fire fatalities per month (fatalities divided by the monthly total of ADFs). This shows that whilst fire fatalities peak in Winter they do not peak in December in most years, despite that month having the largest peak for dwelling fires each year.

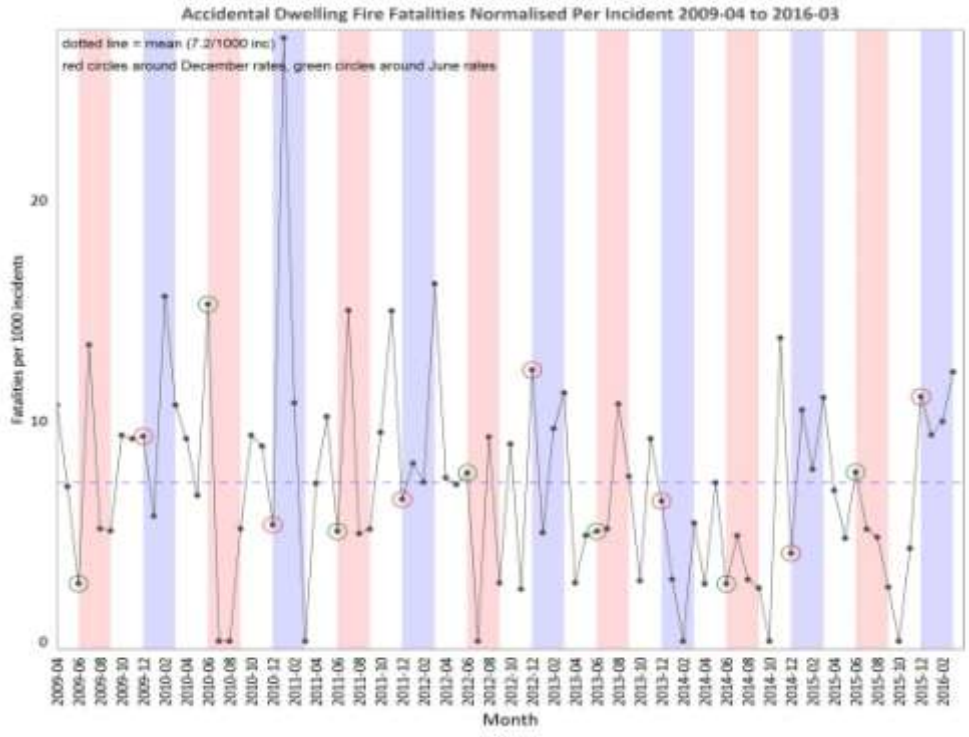

Figure 15: Normalised fire fatality rates per month

Figure 16 above shows that *the rate of dwelling fire fatalities is in most cases lower in December than the other winter months, and very little different to the rate for June each year*. This runs counter to expectations, particularly in light of the average 17% increase in the rate of accidental dwelling fires in the month of December and the average 7% reduction in the summer months mentioned earlier.

One potential explanation for this phenomenon which requires further research to prove or disprove would be that the seasonal differences in accidental dwelling fire patterns may be associated for the most part with the less-severe types of accidental dwelling fire, not the relatively small proportion of fires which result in loss of life.

Previous work undertaken by SFRS in testing the Cheshire model of fire severity against the Fife model developed locally by WM Ron Nairn showed that only around 6% of all accidental dwelling fires fall into the most serious categories of fire severity.

A four-season view of the number of accidental dwelling fire fatalities per thousand incidents shows a peak in the winter season, but the range is very wide and none of the season boxplots test as significantly different to the mean value of 21 fatalities per thousand incidents per season.

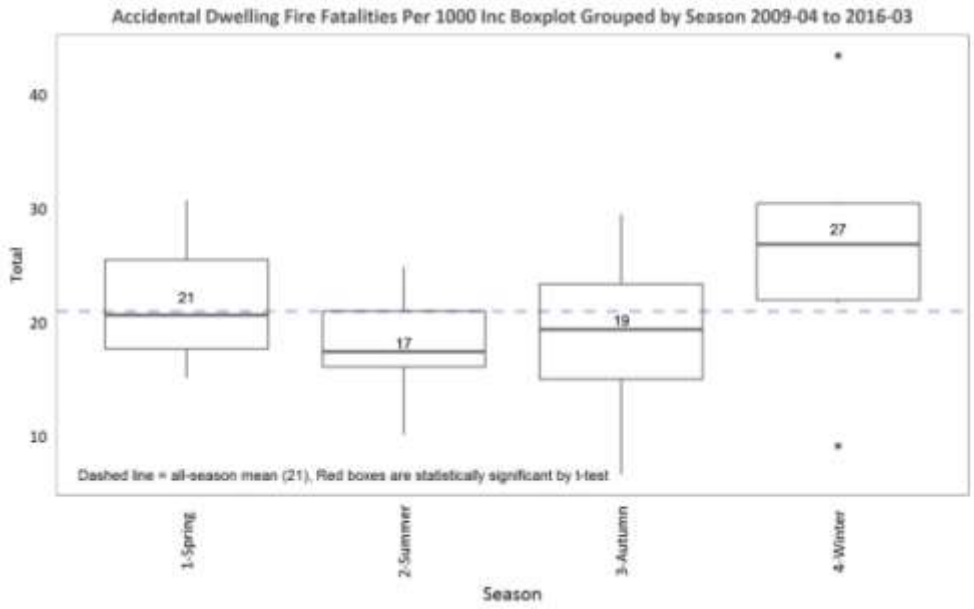

Figure 16: Seasonal accidental dwelling fire fatalities per thousand incidents

Previous studies

There appear to be very few previous studies published on dwelling fires patterns and seasonality. An older study conducted by London Fire Brigade in 2003[2] states that "*unintentional dwelling fire deaths follows a periodic cycle over the course of the year, with more than three times the number of deaths in winter months (November–February) than in the summer months (June–August)*" (the met-office definition of winter which we use in this paper, December to February, covers a narrower period than mentioned by London).

The London paper analysed fire deaths between 1996 and 2000, well before the introduction of Integrated Risk Management Planning and the provision of home fire safety visits for householders, so it is possible that the study reflected the reality of the time and not what would be found now.

A more recent study from 2014 in the Wirral in Merseyside[3] found that "*Fire fatalities followed a seasonal trend, with the highest number of fatalities occurring in the winter months, peaking in January*". The Wirral is a much smaller area with far lower population and far fewer dwelling fires each year than for Scotland as a whole, and with known deprivation issues. The figures quoted in the study are thus not directly comparable to our own situation.

[2] Holborn, P. G., P. F. Nolan, and J. Golt. "An analysis of fatal unintentional dwelling fires investigated by London Fire Brigade between 1996 and 2000." Fire Safety Journal 38.1 (2003): 1-42.
[3] Donaldson, Anna. "ACCIDENTAL DWELLING FIRES IN WIRRAL." (2014).

Appendix 1: Tabulated Statistics

Table 1: Statistics for Accidental Dwelling Fires by Month

Fiscal Month	Overall Mean	Overall Median	Min	Lower Quartile	Mean	Median	Upper Quartile	Max	t test	t test %
01-Apr	422	418	378	396	419	420	438	467	0.792	79.2
02-May	422	418	393	418	423	422	428	454	0.889	88.9
03-Jun	422	418	383	389	393	393	397	401	0.000	0.0
04-Jul	422	418	343	374	403	394	433	467	0.301	30.1
05-Aug	422	418	358	382	397	392	417	432	0.049	4.9
06-Sep	422	418	379	394	399	400	405	417	0.002	0.2
07-Oct	422	418	365	407	415	423	429	448	0.543	54.3
08-Nov	422	418	364	414	427	436	444	475	0.711	71.1
09-Dec	422	418	451	469	498	488	520	570	0.003	0.3
10-Jan	422	418	358	418	448	439	486	530	0.282	28.2
11-Feb	422	418	317	394	407	415	432	463	0.428	42.8
12-Mar	422	418	374	420	430	432	448	467	0.516	51.6

Table 2: Statistics for Deliberate Dwelling Fires by Month

Fiscal Month	Overall Mean	Overall Median	Min	Lower Quartile	Mean	Median	Upper Quartile	Max	t test	t test %
01-Apr	72	66	49	58	74	71	78	125	0.864	86.4
02-May	72	66	50	52	78	87	97	114	0.557	55.7
03-Jun	72	66	50	58	75	72	88	109	0.749	74.9
04-Jul	72	66	44	62	79	80	96	114	0.485	48.5
05-Aug	72	66	39	49	69	63	90	105	0.803	80.3
06-Sep	72	66	38	58	67	66	79	94	0.549	54.9
07-Oct	72	66	48	57	73	67	88	106	0.919	91.9
08-Nov	72	66	56	64	86	75	106	133	0.251	25.1
09-Dec	72	66	47	59	70	61	80	101	0.745	74.5
10-Jan	72	66	46	52	63	63	72	88	0.187	18.7
11-Feb	72	66	26	43	58	53	77	85	0.143	14.3
12-Mar	72	66	40	50	68	72	84	94	0.608	60.8

Table 3: Statistics for Accidental Dwelling Fire Fatalities by Month

Fiscal Month	Overall Mean	Overall Median	Min	Lower Quartile	Mean	Median	Upper Quartile	Max	t test	t test %
01-Apr	3	3	1	2	3	3	4	5	0.805	80.5
02-May	3	3	2	2	3	3	3	4	0.604	60.4
03-Jun	3	3	1	2	3	2	3	6	0.534	53.4
04-Jul	3	3	0	1	3	2	4	7	0.793	79.3
05-Aug	3	3	0	2	2	2	3	4	0.172	17.2
06-Sep	3	3	1	1	2	2	2	3	0.004	0.4
07-Oct	3	3	0	0	2	4	4	4	0.476	47.6
08-Nov	3	3	1	3	4	4	4	6	0.310	31.0
09-Dec	3	3	2	3	4	3	5	6	0.172	17.2
10-Jan	3	3	1	2	4	4	4	12	0.334	33.4
11-Feb	3	3	0	3	4	4	4	7	0.411	41.1
12-Mar	3	3	0	4	4	5	5	7	0.244	24.4

Table 4: Statistics for Accidental Dwelling Fire Fatalities Per Thousand Incidents by Month

Fiscal Month	Overall Mean	Overall Median	Min	Lower Quartile	Mean	Median	Upper Quartile	Max	t test	t test %
01-Apr	7	7	3	5	7	7	8	11	0.768	76.8
02-May	7	7	5	6	7	7	7	10	0.774	77.4
03-Jun	7	7	3	4	7	5	8	15	0.787	78.7
04-Jul	7	7	0	2	6	5	9	15	0.732	73.2
05-Aug	7	7	0	4	5	5	7	11	0.280	28.0
06-Sep	7	7	2	3	4	5	5	7	0.009	0.9
07-Oct	7	7	0	1	6	9	9	9	0.473	47.3
08-Nov	7	7	2	7	9	9	11	15	0.309	30.9
09-Dec	7	7	4	6	8	6	10	12	0.515	51.5
10-Jan	7	7	3	5	10	8	10	27	0.400	40.0
11-Feb	7	7	0	7	9	10	10	16	0.374	37.4
12-Mar	7	7	0	8	10	11	12	16	0.250	25.0

Appendix 2: List of Charts and Tables

Charts

Tables