

Pedestrian Footfall

The data set **Pedestrian Footfall** contains daily pedestrian footfall measured by counters in four locations in Dublin City centre. The locations are Capel Street, Henry Street, Mary Street and O'Connell Street. For each day of 2015 the daily footfall for each of the four locations is provided in a csv file with four columns called *date*, *in*, *out* and *total* where *total* is the sum of *in* and *out*. The data set is published by Dublin City Council and is hosted on the data.gov.ie site under the title *Pedestrian Footfall*.

Additional Data Sets

National Roads Authority/Road Safety Authority road accident data file 1996-2013.

Format

The file dimensions for each location are 365 rows for each day of year by four columns containing the variables *date*, *in*, *out* and *total*.

Reason for selecting Pedestrian Footfall

This data set was selected for two reasons. Pedestrian footfall is a useful measure of exposure which can be linked to pedestrian accidents. This may allow researchers to determine if variation in accident rates for pedestrians, particularly accidents that occur during variable daylight hours, are explained to some extent by variable levels of pedestrian footfall. The second reason is to showcase the use of time series intervention analysis as a useful tool to determine the impact of holidays and other special days throughout the year on footfall levels.

Data Preparation

The data files for each location were merged into a single Excel file with five columns called *date*, *in*, *out*, *total* and *street name*.

Quality control checks were performed on the data which revealed data gaps for quarter 2 (April, May and June) for the O'Connell Street site as shown in Table 1.1. Two daily results for 6th October and 29th December were absent for Henry Street. The recorded value for 10th October (in excess of 70,000) for Henry Street was substantially higher than any other reading suggesting an equipment malfunction. Checks on this date to see if any events taking place in Dublin City centre provided no further clues. The Capel Street and Mary Street results were complete with flow rates provided for each day of 2015.

Location	Missing Counts
O'Connell Street	8 April - 2 May 10 May - 6 June 15 - 30 June 1 - 7 August 29 August - 10 September 9 -13 December
Mary Street	None
Henry Street	6 October 29 December
Capel Street	None

Table 1.1: Missing count data by location, 2015

The data preparation also included formatting the data to allow a time series model of pedestrian footfall to be developed for the Capel Street site. This involved determining the impact of interventions such as bank holidays and other special days on footfall as well as taking into account correlation patterns in the data series. Indicator variables for each of 18 possibly significant days were generated which took the value 1 for the day of the intervention and 0 for all other days.

Software

The analysis involved the use of the visualisation software Tableau (www.Tableau.com) and the statistical exploratory and visualisation software DataDesk (www.DataDesk.com). Time series models for the pedestrian footfalls were analysed using the application SCA scientific computing associates (www.sca.com)

Outcome and Impact

The outcome of this exploratory work is that pedestrian footfall does not seem to vary significantly throughout the year and that the large variation in pedestrian fatal accidents is likely to be explained by variable daylight hours rather than footfall variation.

A time series intervention model was developed for the Capel Street location which estimates the effects of holidays and special days on footfall.

This work could be extended to assess the impact of holiday interventions on other sites and over a longer time window which might be of benefit to local businesses. The research on pedestrian accidents could be extended to assess the impact of daylight saving time on accidents e.g. the impact of the clock changes in winter and summer.

Timeline for Completion

The project is completed.

Progress Report - Visualisation of Pedestrian Footfall

The daily time series of the total daily pedestrian footfall for all four city centre locations is shown in Figure 1.1. As mentioned earlier visual analysis illustrates a number of data gaps for O'Connell Street and two for Henry Street which are listed in Table 1.1. In addition, Henry Street reports a spike in footfall on 10th October with a count in excess of 70,000. There are no spikes at the other nearby locations for this date. No reports were found of special events taking place in Dublin City centre on this day suggesting the possibility of a machine malfunction.

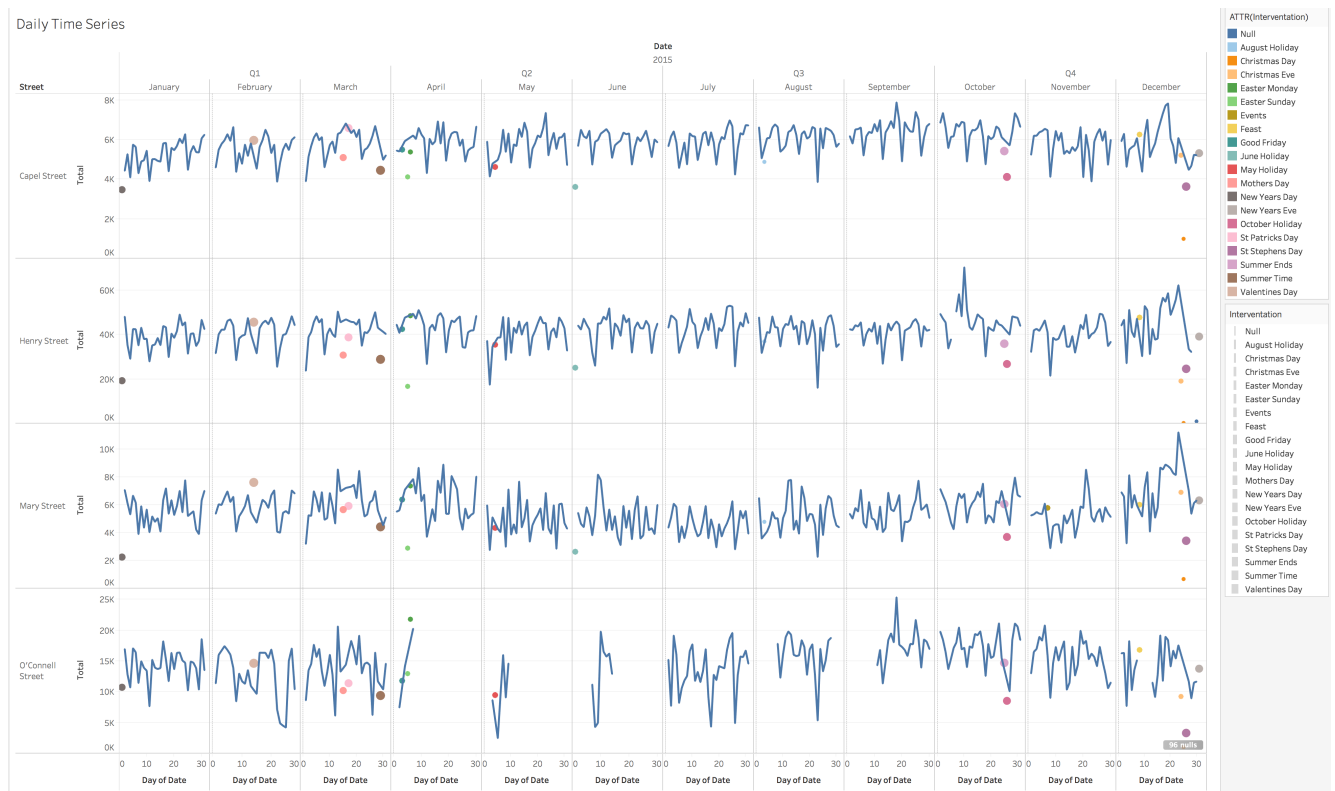


Figure 1.1 Daily Pedestrian footfall for four locations in Dublin City Centre, 2015

The plot also shows the volatility in the Christmas period for all locations which is also evident, to a lesser extent, for bank holidays and other significant days. These impacts can be visualised interactively by users by mousing over the plot shown in Figure 1.1.

A surprising result from visual inspection of Figure 1.1 is that footfall tends to have a cyclical weekly pattern which seems to remain broadly similar all year with little or no summer/winter effect. This is an important observation as pedestrian accidents, unlike all other accident types, have a very strong seasonal component. This is particularly so for fatal pedestrian accidents which we will investigate in a later section. However the visual analysis suggests that seasonality of pedestrian accidents is not explained by seasonality of footfall i.e. there are not more accidents in winter because there is higher amount of pedestrian footfall activity - commonly referred to exposure by researchers.

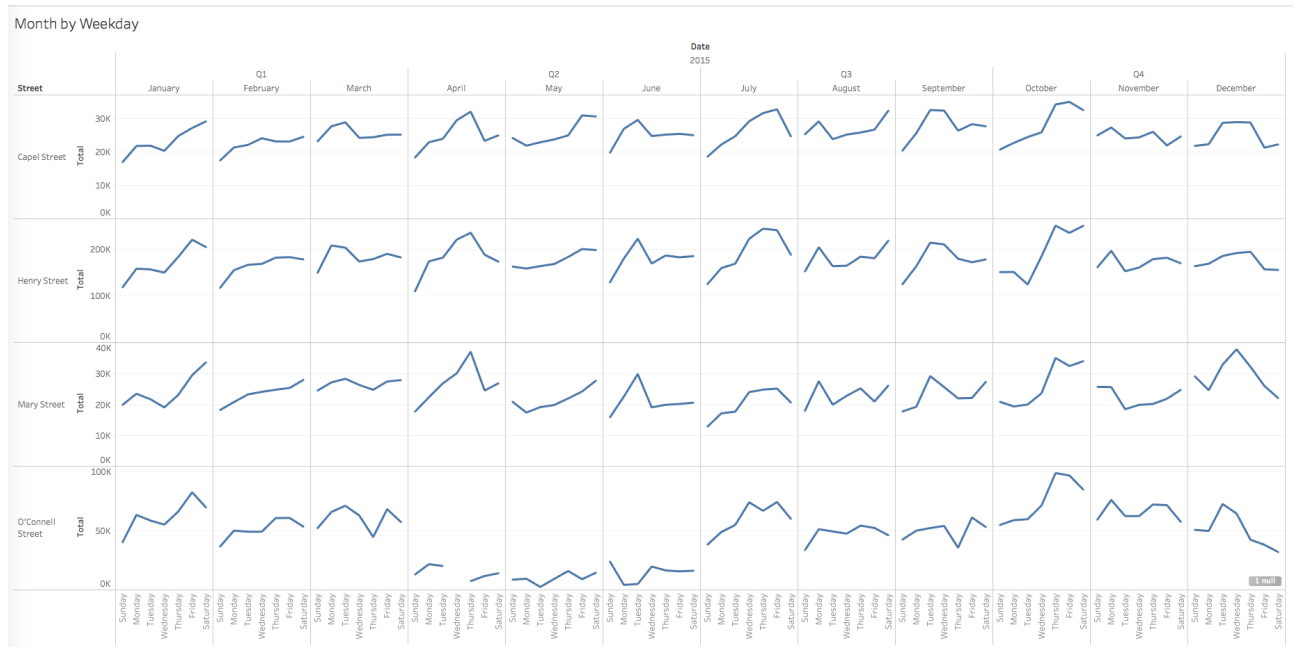


Figure 1.2 Pedestrian footfall by weekday and quarter for four locations in Dublin City Centre, 2015

Figure 1.2 shows the footfall by weekday for each month throughout 2015. This plot shows that, in general, the lowest footfall are recorded on Sundays with rates generally increasing throughout the week.

2. Statistical Analysis of Capel Street Pedestrian Footfall using Time Series Intervention Analysis

While the visual analysis in the previous section provides an exploratory assessment of footfall, a formal time series intervention model was developed for Capel Street. This model provided a deeper insight into the characteristics of footfall for this location. As the visual analysis suggested the statistical model suggested that the main component of variation was found to be a cyclical day of week pattern with no apparent seasonality component.

The model also assessed the statistical significance of 18 days throughout the year which could influence footfall and whose incorporation into the model would provide a more realistic fit. The error term was also modelled to ensure that correlations between counts were fully taken into account and involved autoregressive and moving average terms. The modelling strategy was based on the development of ARIMA (Autoregressive Integrated Moving Average) models based on the pioneering work of Box and Jenkins.

The largest intervention was as might be expected Christmas Day which reduced footfall by over 5,500 as shown in Figure 1.3. The May, June, August and October bank holidays also reported statistically significant reductions in footfall with October reporting the largest reduction of over 1,500. Surprisingly the intervention of Easter suggested no significant change in footfall. The only significant increase in footfall was reported for December 8th which is traditionally a major shopping day.

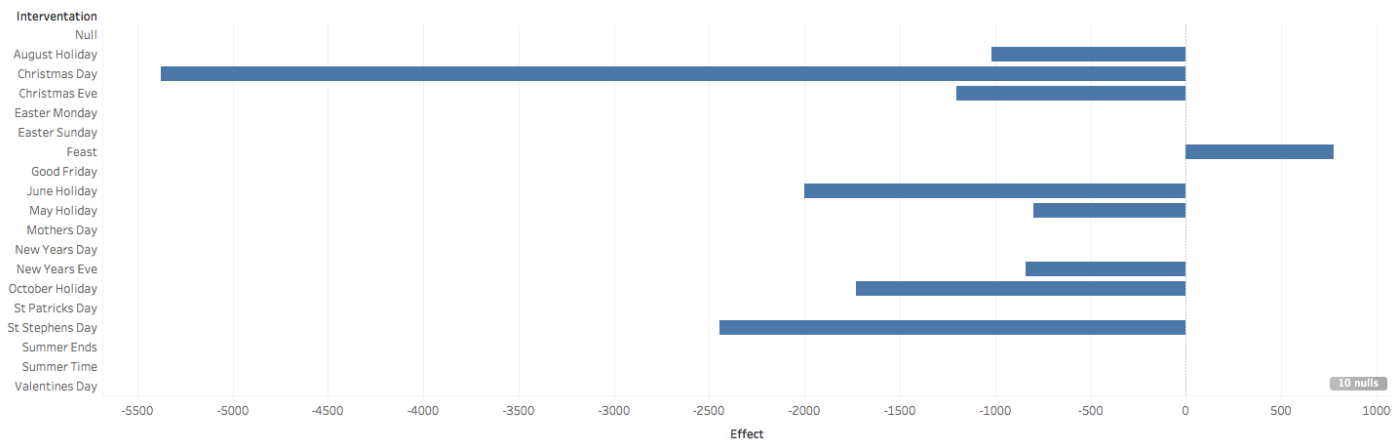


Figure 1.3 Statistical significant days for pedestrian footfall

The formal model is shown in Appendix 1. The final fit of the time series model for Capel Street can be described as:

$$Y_t = Y_{t-7} + \text{special daily interventions} + \text{Noise}$$

This model suggests that daily pedestrian footfall on any day is equal to the footfall in the previous week plus the impact of the special daily events and a noise term which is described in the time series notation as an ARIMA(1,0,0)(0,1,1)₇ model. A preliminary modelling exercise for Mary Street suggests a similar model to Capel Street.

The fit of this simple model to the data is reasonably good with the predicted model explaining over 66 per cent of the variation in daily pedestrian footfall. This fit can be seen in a plot of the actual data footfall (blue) together with the predicted footfall (green) is shown in Figure 1.4.

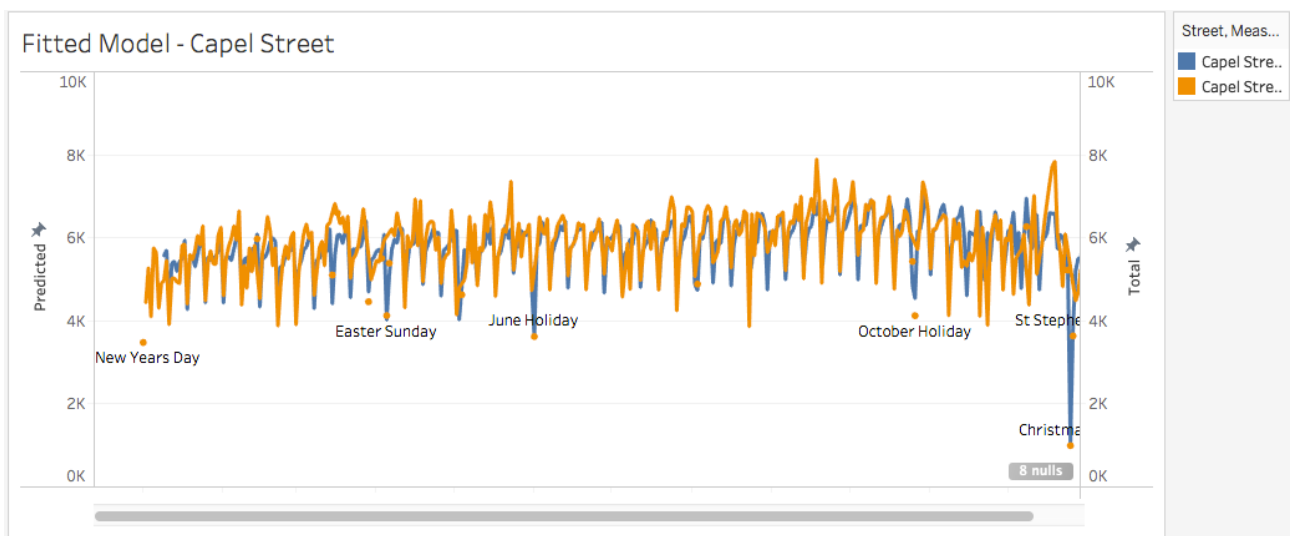


Figure 1.4 Pedestrian footfall and model fit

3. Accidents and Footfall

Pedestrian count data is a valuable resource for road accident researchers as it allows for accident rates to be adjusted for pedestrian footfall or what is called exposure. Pedestrian accidents, unlike all other accident types, have a very strong seasonal component, particularly fatal pedestrian accidents. It is of interest to researchers to determine if this seasonal pattern is influenced in any way by the seasonality of footfall. For example, there may be more accidents in winter because there is a higher level of pedestrian activity. However, the time series model developed for Capel Street suggested no seasonal effect while visual analysis of the other locations suggests a similar pattern.

To assess the characteristics associated with pedestrian accidents in Dublin City Centre (and in the country overall) road accident data from 1996 to 2013 (the latest year for which data is available) was plotted in Figure 1.5.

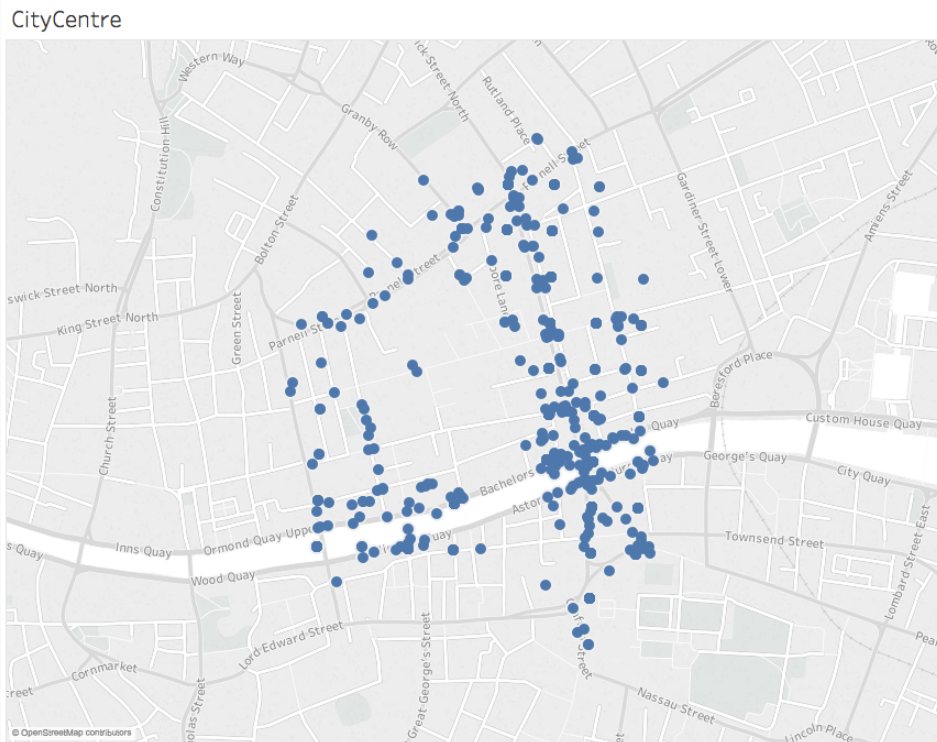


Figure 1.5: Accidents in Dublin City Centre Area, 1996-2013

The majority of the accidents in Figure 1.5 are pedestrian and it is this category that has reported the largest reduction in road accidents. This can be seen in the trellis plot in Figure 1.6 which shows the primary collision type by severity. Incidentally, it is interesting to note the substantial reduction in pedestrian accidents which commenced in around 2002.

Primary Colission Type

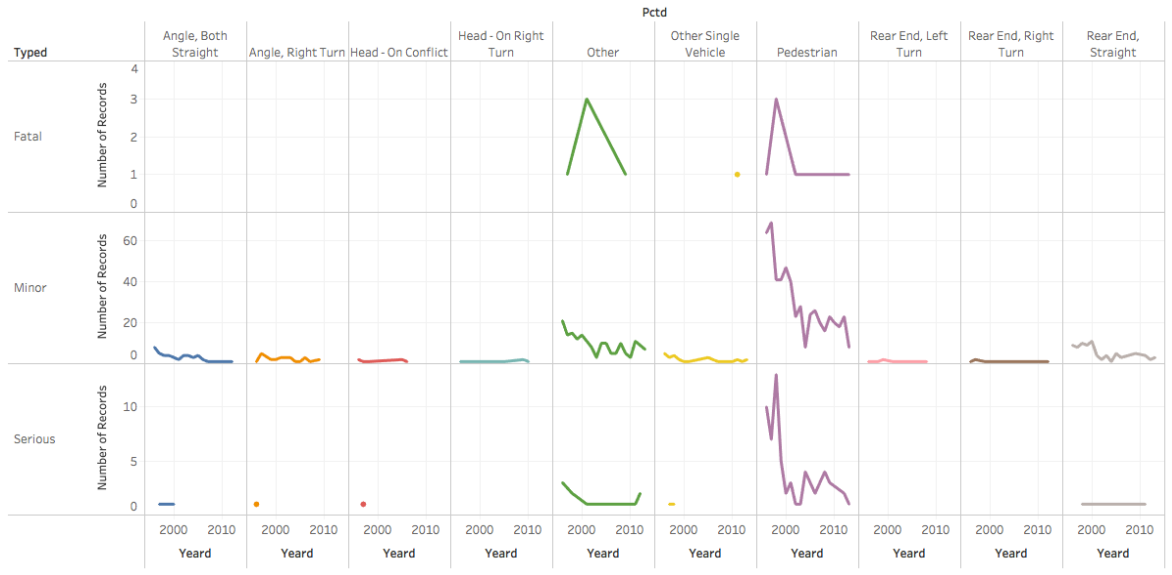


Figure 1.6: Primary Collision Type of Accidents in Dublin City Centre Area, 1996-2013

To explore the causal factors associated with fatal pedestrian accidents a larger data set is required as the numbers in Dublin City centre are not sufficiently large - particularly fatal pedestrian accidents. Plotting the number of pedestrian fatal accidents for the whole country between 1996 and 2013 reveals a strong seasonal U shape as shown in Figure 1.7.

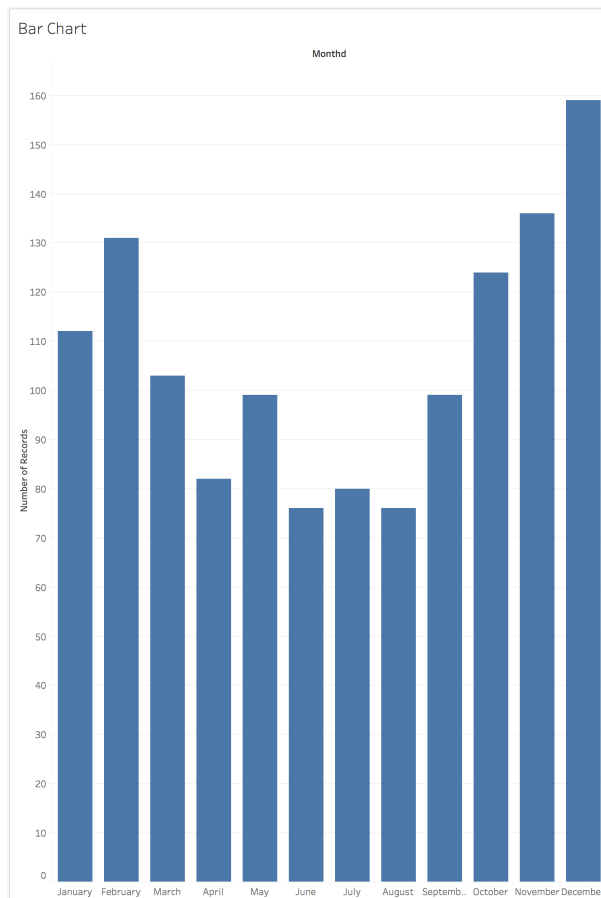


Figure 1.7: Pedestrian fatal accidents - all hours, 1996-2013

This pattern is perhaps explained by accidents that occur during variable daylight hours between 4 and 10pm throughout the year (and the small number that occur between 6pm and 8pm) which are plotted in Figure 1.8 (left plot). Removing variable daylight hours no U shape is evident as seen in the right plot.

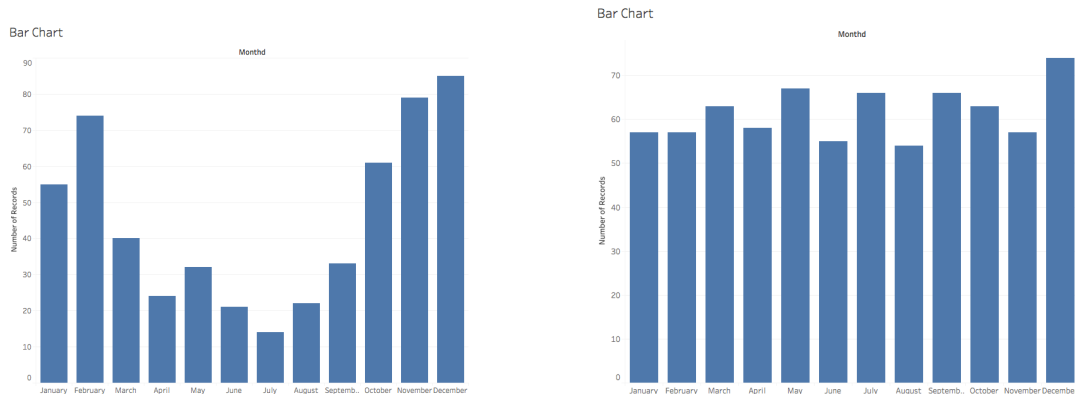


Figure 1.8: Pedestrian fatal accidents in Ireland 1996-2013 during variable daylight hours (left) and excluding variable daylight hours (right).

This suggests that the U shape pattern in Figure 1.7 is explained by variable daylight hours. The greater the amount of darkness between 4pm and 10pm the higher the number of pedestrian accidents. Therefore, the winter months report high levels of pedestrian accidents when there is more darkness during this time period and vice versa. The U pattern is absent for all other accident types. For example, the equivalent pattern for Head-On accidents is shown in Figure 1.9 where the left hand plot refers to accidents that occur during variable daylight hours between 4pm and 10pm and the right hand plot for all other hours.

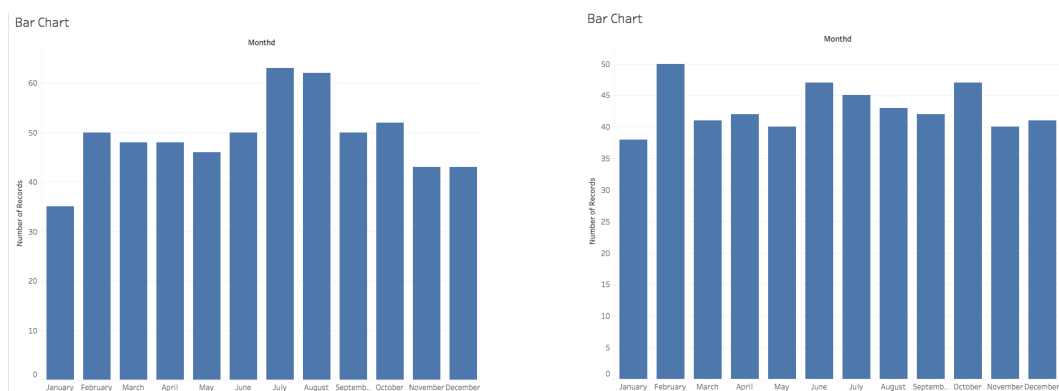


Figure 1.9: Head-on fatal accidents in Ireland 1996-2013 during variable daylight hours (left) and all other hours excluding variable daylight hours (right).

Could Footfall explain the U Shape in Pedestrian Accidents?

In the large body of literature on the impact of variable daylight hours on accident rates a common concern is that the absence of pedestrian footfall data means that the increased rates may to some extent be explained by higher pedestrian movements during winter and not just increased levels of darkness. However, the statistical analysis of Capel Street footfall and the visual analysis of the other city centre locations suggests that footfall rates are broadly constant throughout the year. This provides evidence of the pivotal role of variable daylight hours on pedestrian accidents.

Appendix 1

Final Model:

$$Y_t = Y_{t-7} + \text{Intervention Pulses} + \text{Noise}$$

Noise is explained by ARIMA(1,0,0)(0,1,1)₇ term.

The estimates of the nine significant daily interventions together with the noise terms is shown below.

Weekday	Name	Intervention Effect (on footfall)	t
NWD	New Years Day	-	Non-significant
Sat	Valentines Day		Non-significant
Sunday	Mothers Day	-	Non-significant
Tues	Paddy's Day	-	Non-significant
Sunday	Summer Time	-	Non-significant
Friday	Good Friday	-	Non-significant
Sunday	Easter	-	Non-significant
Monday	Easter	-	Non-significant
Monday	May Bank Holiday	-800	-1.74
Monday	June Bank Holiday	-2000	-4.74
Monday	August Bank Holiday	-1021	-2.23
Sunday	Summer Ends		Non-significant
Monday	October	-1730	-3.76
Tues	December 8th	775	1.67
Thurs	Christmas Eve	-1205	-2.42
Fri	Christmas Day	-5376	-10.3
Sat	St StephensDay	-2448	-4.9
Thursday	New Years Eye	-838	-1.66
AR(1)		0.8613	30.73
MA(7)		0.3252	6.46