

# 263 Group 19 - Group Model

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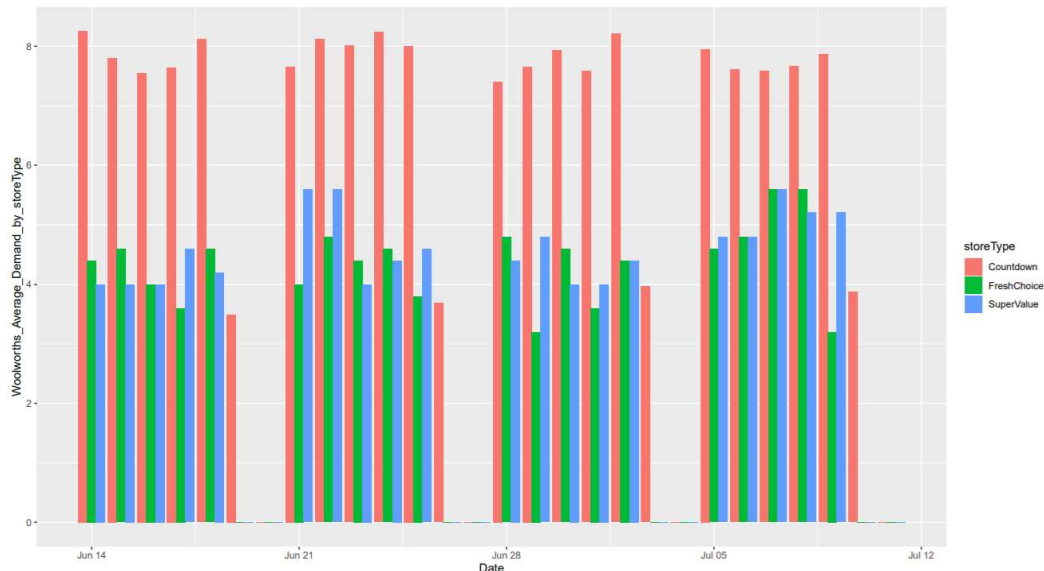
## Data Analysis

We were given data for past daily demand and location of the stores, as well as approximate inter store travel distances and durations. Analysing the locations and demand will be vital for our model formulation (and hence recommendation). We decided against analysing the travel data as it will not provide much insight.

## Demands

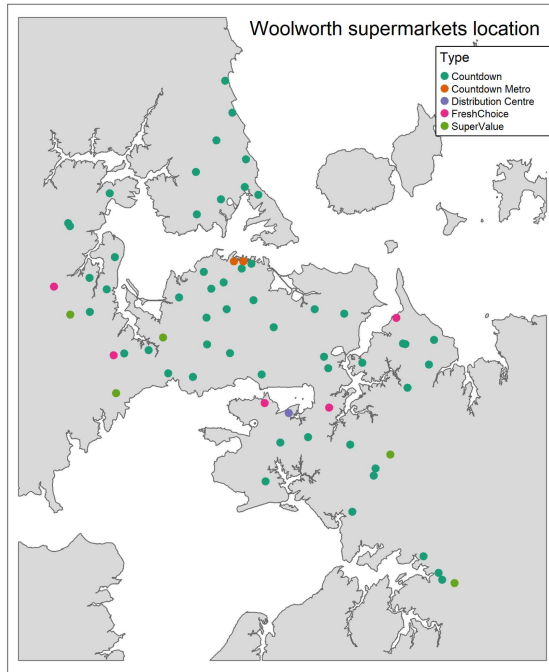


The above graph shows the average daily demand of each individual store (taken across the whole period of given data) with standard deviation. This shows that average demand between similar stores does not deviate significantly, and hence grouping stores by their type may provide useful information and accuracy.

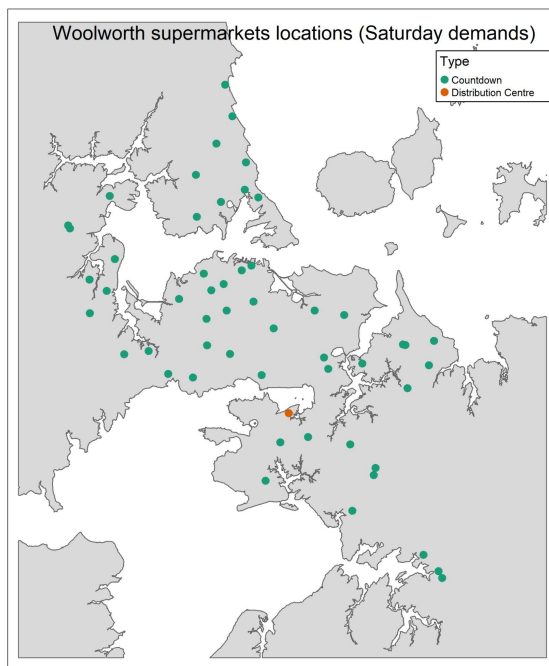


Above is the plot of average daily demands of each store type. From this we can clearly see that Countdown stores have significantly higher average demand than the other stores. We can also see that the variation in average daily demand every week is uniform (no trend) throughout the recorded period of time. The plot tells us that demand on Saturdays is also very different from weekday demand, and that there is no demand on Sundays, hence we must consider Saturdays separately to weekdays. We will use this analysis to estimate the average daily demands of each store type on weekdays and the weekend.

### Locations



The left geospatial visualisation shows the location of all woolworths stores in the auckland region, coloured by their store type. We used this visualisation to help us split up the stores into regions, which helped us in route generation. We also decided to further split Countdown stores into 'Countdown' and 'Countdown Metro', as the smaller Metro stores have similar demands to FreshChoice and SuperValue stores, as well as having no demand on Saturday, as opposed to normal Countdown stores.



This visualisation only shows the stores that are open on Saturdays. This confirms that demands on Saturdays cannot be assumed the same as weekday demands, hence we must run our LP separately for Saturdays.

## Route Generation

### Regions

Using the visualization above and the *WoolworthsLocations.csv* file, we split the stores up into regions based on their latitude and longitude (see below) . We chose five regions: north, south, east, west and central. This was then appended as an extra column to the location data, and saved as a new csv. The groupings were as follows:

	<b>Lat</b>	<b>Long</b>
<b>North</b>	$\geq -36.811$	$\geq 174.725$
<b>South</b>	$< -36.945$	
<b>East</b>	$\geq -36.945$	$\geq 174.829$
<b>West</b>	$\geq -36.945$	$< 174.710$
<b>Central</b>	$\geq -36.945, < -36.811$	$\geq 174.710, < 174.829$

### Routes

We opted to initially create all routes by creating all permutations within regions involving 1, 2, 3, 4 and 5 nodes (stops). We then refined the number of routes by removing routes that exceed our given constraints. The constraints were as follows:

- Total trip time  $\leq 14,400$ s (using given travel time in *WoolworthsTravelDurations.csv*)
- Total demand  $\leq 26$  pallets (using average weekly/saturday demand)

This left us with 43041 feasible routes to use in our weekday model and 405395 feasible routes to use in our Saturday model.

### Costs

We know from the given information that:

- Each pallet takes 7.5 mins to unload.
- Average demand of each type of store (from DA section).
  - We used an average demand of:
    - 7.5 pallets on weekdays for Countdown stores.
    - 4 pallets on Saturday for Countdown stores.
    - 4.5 pallets on weekdays for FreshChoice and SuperValue stores.
- Approximate travel durations are given (*WoolworthsTravelDurations.csv*).
- Woolworths trucks cost \$225/hour
  - Overtime costs \$275/hour
- Extra trucks can be hired for \$2000/4hr flat rate.

However, as we have constrained the total time of our routes to be  $\leq 14,400$ s (4hrs), we do not need to worry about overtime pay. We will also for the time being not consider wet leasing extra trucks. Hence our cost formula for each route is as follows:

```

for route in routes do
    for stop in route do
        cost += (7.5*aveDemand[stop] + travelDuration[stop][nextStop]) * 225
    end
end

```

## Model Formulation

### Assumptions

- All routes take under 4 hrs (from route selection) and therefore overtime does not have to be considered.
- We only have 22 routes on weekdays and 12 routes on Saturday, which are both well under the limit of 60 trips per day. Thus, we do not have to consider wet leasing trucks for now.
- Demand can be split into weekdays and Saturdays and averaged accordingly (demand is zero on Sunday across all stores).

### Mathematical Formulation

Let  $R_k$  (boolean) = 1 if route  $k$  has exactly 1 truck going along it each day.

$C_k$  (float) = the total cost of one truck on route  $k$  in \$/trip

$S_l$  (int) = the number of times store  $l$  is visited each day

$$\text{MIN} \quad \sum_{k=1}^n C_k * R_k$$

$$\text{subject to :} \quad \sum_{k=1}^n R_k \leq 60$$

$$S_l = 1, \forall l$$

## Results

Our git repository can be accessed via the link below. Running our *WoolworthsLp.py* file in the repository will yield the same results as observed on the following page.

<https://github.com/bugn200/263-OR-Project.git>

*Weekdays:* As seen below, our minimised objective value comes out to \$6850.10 per weekday. This was an optimal solution and the 22 different routes are listed respectively (each route works as follows : Distribution Centre → First store in list → ... → Final store in list → Distribution Centre).

```

Option for printingOptions changed from normal to all
Total time (CPU seconds):      1.11  (Wallclock seconds):      1.11

Status: Optimal

('X_1551.0', ('Countdown Manukau Mall', 'Countdown Manukau', 'Countdown Mangere East'))
('X_1716.0', ('Countdown Manurewa', 'Countdown Takanini', 'Countdown Papatoetoe'))
('X_17893.0', ('Countdown Te Atatu South', 'Countdown Henderson', 'SuperValue Palomino', 'SuperValue Titirangi'))
('X_2422.0', ('Countdown Mangere Mall', 'Countdown Airport'))
('X_2546.0', ('Countdown Aviemore Drive', 'Countdown Highland Park', 'FreshChoice Half Moon Bay', 'FreshChoice Otahuhu'))
('X_28412.0', ('Countdown Hobsonville', 'Countdown Glenfield', 'Countdown Blockhouse Bay'))
('X_28753.0', ('Countdown Kelston', 'FreshChoice Glen Eden', 'Countdown Lynmall'))
('X_28983.0', ('Countdown Lincoln Road', 'FreshChoice Ranui', 'SuperValue Avondale'))
('X_29973.0', ('Countdown Westgate', 'Countdown Northwest', 'Countdown Te Atatu'))
('X_31517.0', ('Countdown Mairangi Bay', 'Countdown Browns Bay', 'Countdown Hauraki Corner'))
('X_31786.0', ('Countdown Takapuna', 'Countdown Milford', 'Countdown Northcote'))
('X_31725.0', ('Countdown Birkenhead', 'Countdown Sunnynook'))
('X_37079.0', ('Countdown Metro Halsey Street', 'Countdown Metro Albert Street', 'Countdown Auckland City', 'Countdown Lynfield'))
('X_39426.0', ('Countdown Grey Lynn Central', 'Countdown Grey Lynn', 'Countdown Mt Roskill'))
('X_39972.0', ('Countdown Mt Eden', 'Countdown Newmarket', 'Countdown Three Kings'))
('X_41013.0', ('Countdown Ponsonby', 'Countdown Victoria Street West', 'Countdown Greenlane'))
('X_4135.0', ('Countdown Meadowbank', 'Countdown St Johns', 'Countdown Botany Downs'))
('X_41470.0', ('Countdown St Lukes', 'Countdown Pt Chevalier', 'Countdown Onehunga'))
('X_4208.0', ('Countdown Meadowlands', 'Countdown Howick', 'Countdown Mt Wellington'))
('X_43040.0', ('FreshChoice Mangere Bridge',))
('X_445.0', ('Countdown Roselands', 'Countdown Papakura', 'SuperValue Papakura', 'SuperValue Flatbush'))
('X_5029.0', ('Countdown Pakuranga', 'Countdown Sylvia Park'))

Minimised Cost for Weedays = $ 6850.1

```

*Saturday:* As seen below, our minimised objective value comes out to \$6850.10 for Saturday. This was an optimal solution and the 12 different routes are listed respectively.

```

Option for printingOptions changed from normal to all
Total time (CPU seconds):      6.40  (Wallclock seconds):      6.40

Status: Optimal

('X_126308.0', ('Countdown Westgate', 'Countdown Northwest', 'Countdown Hobsonville', 'Countdown Glenfield', 'Countdown Te Atatu'))
('X_134496.0', ('Countdown Te Atatu South', 'Countdown Lincoln Road', 'Countdown Henderson', 'Countdown Blockhouse Bay'))
('X_136625.0', ('Countdown Lynmall', 'Countdown Kelston'))
('X_138029.0', ('Countdown Sunnynook', 'Countdown Mairangi Bay', 'Countdown Browns Bay', 'Countdown Northcote'))
('X_138216.0', ('Countdown Takapuna', 'Countdown Hauraki Corner', 'Countdown Milford', 'Countdown Birkenhead'))
('X_165950.0', ('Countdown Greenlane', 'Countdown Newmarket', 'Countdown Victoria Street West', 'Countdown Auckland City', 'Countdown Three Kings'))
('X_18134.0', ('Countdown Manurewa', 'Countdown Takanini', 'Countdown Roselands', 'Countdown Papakura', 'Countdown Mangere Mall'))
('X_229306.0', ('Countdown Mt Eden', 'Countdown Grey Lynn Central', 'Countdown Ponsonby', 'Countdown Grey Lynn', 'Countdown Onehunga'))
('X_36571.0', ('Countdown Aviemore Drive', 'Countdown Highland Park', 'Countdown Meadowlands', 'Countdown Howick', 'Countdown Pakuranga'))
('X_390710.0', ('Countdown Mt Roskill', 'Countdown St Lukes', 'Countdown Pt Chevalier', 'Countdown Lynfield'))
('X_5136.0', ('Countdown Mangere East', 'Countdown Papatoetoe', 'Countdown Manukau', 'Countdown Manukau Mall', 'Countdown Airport'))
('X_65651.0', ('Countdown Sylvia Park', 'Countdown Mt Wellington', 'Countdown St Johns', 'Countdown Meadowbank', 'Countdown Botany Downs'))

Minimised Cost for Saturday = $ 4484.47
PS C:\Users\admin\Documents\Uni Work\ENGS21263\OR\OR Project>

```