SENIOR'S HOUSING PREFERENCES

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Introduction

With the growing number of seniors in Canada, there will be some major changes that must occur to adjust for the new demographics of the country. Baby boomers- born between 1946 and 1965- have started retiring with the first wave turning 65 in 2011 [1]. From 2011 to 2016, the number of retirees has increased by 20% [2]. With a variety of critical issues due to this impending issue, CIBC is predicting that the average Canadian will need $756,000 to retire [3]. 53% of Canadians don't think they are saving enough [3]. 37% haven't even thought about retirement [3]. Government plans such as the Canada Pension Plan, Old Age Security and Guaranteed Income Supplement are being stretched thin [3]. Therefore, the pre-existing and upcoming resources must be efficiently allocated to maximize its efficacy in this high demand market. One of the ways to improve policies and plans are to better understand the lifestyle preferences of seniors. Looking at their housing preferences may provide new insights into what is most necessary for the public and private sectors to provide for the incoming flood of retiring seniors.

1) Previous Research

A previous study was conducted regarding the factors that predict relocation among older adults. In Lori Weeks, Janice Keefe and Dany Macdonald's paper, they collected and analyzed data from 1,015 community-dwelling seniors in Canada [1]. Using a logistic regression analysis, they found that relocation was significantly related to gender, age, household income, province resided in, driving status, satisfaction with current house, and unmet heavy cleaning needs [1]. The researchers concluded that policies and services need to first identify those most likely to move as that seems to be an issue [1].

Another study in the US was conducted to find the socioeconomic determinants of the housing decisions of elderly homeowners. In this book by Leon Pastalan, the author finds that seniors prefer finding a new house that they can own as opposed to rent if they can afford to [2]. This is because this is a more permanent solution which is better suited to seniors' needs as they can live closer to family and friends [2]. Furthermore, this gives them the freedom to customize the house suited to their needs by adding in ramps, grab bars and other accessibility components for more comfortable living [2]. Thirdly, Pastalan notes that accessibility to healthcare services in a proximity to their living arrangement also has a positive impact on seniors' housing decisions [2].

From these two papers, it seems that relocation is strongly associated with a senior's income and into a house that better satisfies their needs by improved accessibility and proximity to healthcare services. The papers however, do not touch upon other factors that may affect a senior's decision to relocate. As governments provide a vast array of senior services, it would be interesting to see how much of a pull this provides in attracting seniors to those communities. Furthermore, as seniors age, they are more likely to stop driving and therefore are more likely

to use public transportation. Seniors may be more susceptible to certain crimes, therefore testing that could provide insights into whether changes in security need to be made. Also, since the two studies were completed in 2012 and 1995, they are outdated and don't address the current baby boom situation to its full extent. First off, public transportation has improved in many big cities, making mobility easier for seniors. Therefore, the initial need for having healthcare services in close vicinity may have diminished. Additionally, the influx of seniors means that the number of seniors relocating is higher and therefore their patterns and preferences might become clearer.

2) Purpose

To accommodate the higher number of seniors, resources such as medical facilities, housing, and transportation be optimized. Therefore, it is vital to understand and quantify exactly what factors go into seniors housing preferences in Calgary. This would show what their utility functions are currently and can help for future urban planning.

2a) Economic Benefit of Project

If the experiment provides decent results, ideally this information could be used for urban planning and economic development. Cities would be able to plan out their new developing areas better and provide better resources to accommodate seniors. This would also optimize the city and government's budget for providing these resources, freeing up money to address other components of the senior crisis. Furthermore, private businesses could identify the most profitable areas/aspects to set up their business to maximize their client base.

3) Data

For this experiment, Calgary has been chosen. Calgary had a total population of 1,239,220 in 2016 and 112,671 were 65 or older [1].

The data is primarily collected from the City of Calgary. The City of Calgary has set up a program called "Open Calgary" which is a data initiative program designed to share data to "facilitate the sharing of information, spark innovative ideas and foster a sense of collaboration among citizens."

From this website, City Census data summarized at the community level was collected for the 2016 and 2014 census. This data primarily consisted of residents and dwelling data. The "residents" data included the number of individuals in each age group, their employment status and whether they owned or rented their house. "Dwellings" data were categorized by the type of dwelling as well as number of residents per dwelling. Additional data regarding community services, business licenses, Seniors services and transit LRT stations were collected from Open Calgary [6] [7] [8] [9] [10] [11]. Most of the supplemental data was also summarized at the community level, except for the LRT data, which only displayed the geographic coordinates of the station. The supplemental datasets also contained a community code which is how the different datasets were joined.

The second data source was the Calgary Police Services website. From this site, monthly community crime statistics were collected for years 2012-2017 [12]. This dataset provided statistics on person and property crimes, disorder, traffic, LRT, domestic conflict, drugs, hate/bias crime, weapons, youth, city centre and gang related crime in Calgary communities [12]. This dataset was joined to the master dataset by community name.

3a) Using City Census data over Census Tract data

There are three main reasons for using community data over census tract data: accuracy, availability, and completeness. As communities are much smaller than census tracts, this allows for a more precise analysis of the area in relation to different resources. City data also provides the ability to evaluate other variables based on a community's characteristics that census tract data does not provide. Furthermore, since the data is collected more frequently, it means that we can use a smaller and sensible time period for better accuracy. Lastly, since this experiment is looking at growth levels of seniors, changes over time are crucial. Since the 2011 census tract was optional, there was missing data due to it being voluntary, and might also have had a disproportional category of people who answered leading to bias. Therefore, comparing the 2011 to 2016 census tract data would have flawed results. While the city census is still optional, the number of individuals opting out will be more similar between the 2014 and 2016 reports as there were no glaring issues with the data collection process.

4) Hypothesis & Methodology

The hypothesis being tested for in this experiment is if the presence of a resource in a community will positively factor into senior's housing choices. Since there are a variety of resources, multiple multi-variable linear regressions will be completed for every type of resource. Naturally as some resources may not be good indicators, it is expected that the initial regressions will have low R^2 values as a single resource should not have a high goodness of fit. However, the final R^2 and regression should represent a normal, accurate multi-variable linear regression. After finding the best predictors, a final regression will be done to ensure accuracy and evaluate the results. A 95% significance level will be used. Since the specific resource may positively or negatively impact the senior's housing choices, a two-tailed test will be completing, meaning that a variable must have a t-value greater than 1.96 and a P-value smaller than 0.025 to be statistically significant. The null and alternative hypothesis are provided below, which will be the general structure for each resource.

$$H_0 = the\ presence\ of\ a\ [resource]\ in\ a\ community\ do\ not\ affect\ senior\ relocation$$

$$H_a = the\ presence\ of\ [resource]\ in\ a\ community\ does\ affect\ senior\ relocation$$

4a) Response Variables and Assumptions

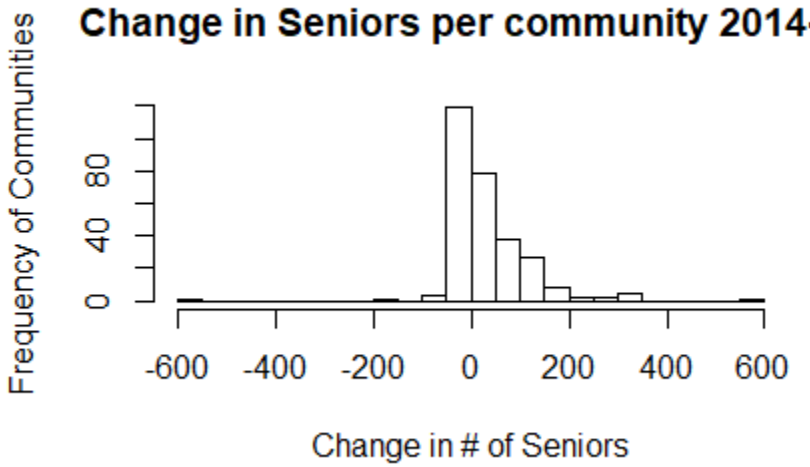
Since the responding variable is the number of seniors residing in a given community, a few adjustments need to be made. First of all, bigger communities or well-established communities will naturally have a higher number of seniors living in it. To account for pre-habitating seniors in the community, instead of just the frequency of seniors in the community, a change in the

number of seniors from 2014 to 2016 was used. This way, senior population growth in a certain community will be presented to see the actual changes in the community's demographics. 2014 and 2016 were chosen as these years provided the most complete Census for demographics, as the 2015 and 2017 censuses did not collect demographic data. Furthermore, a shorter time period was best as longer time periods would have had more unaccountable factors to deal with – when exactly the dependent variable (amenity or service) was founded as well as more issues with new community boundaries etc.

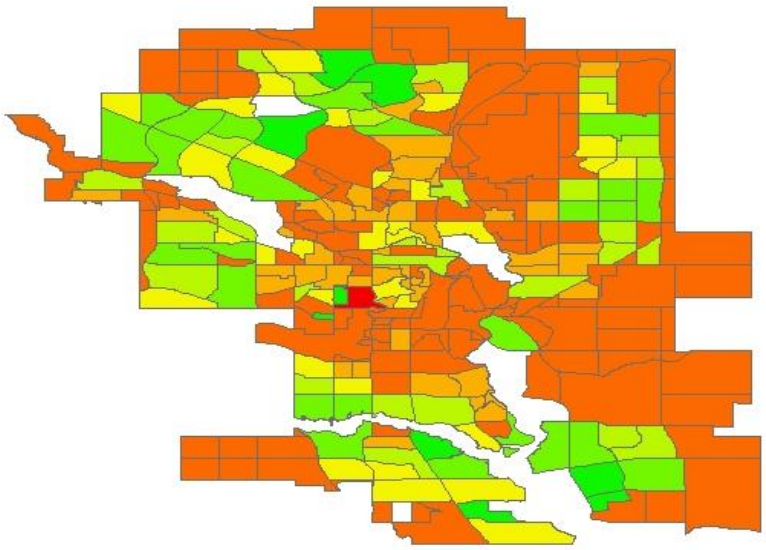
$$\Delta\, Seniors_{Community} = \#\, Seniors_{2016\, Community} - \#\, Seniors_{2014\, Community}$$

A second adjustment was made to account for the natural aging process. Seniors for the purpose of this experiment are individuals who are 65 or older. This gives rise to the issue that individuals aged 63 or 64 in 2014 would not qualify as seniors in the 2014 census but would qualify as seniors in 2016. Even if the individual did not move into the community, this would have shown a senior growth as the number of seniors increased, which would have given false data. The best solution would have been panel data where it would have been possible to see exactly how many individuals were 63 or 64, but as the data was in summary statistics grouped by community, an adjustment had to be made. This was accounted for by finding a "standardized senior growth rate" for a community by calculating the difference of the nominal senior growth rate per community by the senior growth rate in Calgary. The senior growth rate in Calgary from the years 2014 to 2016 was 9.46%. This standardized the growth rate through the assumption that 63 and 64 year olds were proportionally distributed throughout Calgary and the formula is shown below.

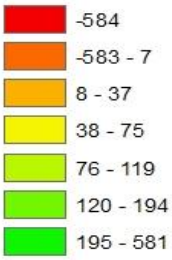
$$Y_{Standardized\ Senior\ Relocation_{Community}} = \frac{x_{\Delta\, Seniors_{Community}} - \mu_{\Delta\, Seniors_{Community}}}{\sigma^2_{\Delta\, Seniors_{Community}}}$$



Calgary



Change in Number of Seniors 2014-16



From the map above, it seems there is a ring that is formed in Calgary. Seniors living inside the ring and close to the city centre decide to move outwards. Seniors living outside the ring seem to move inwards. Briefly, this "ring" is essentially the outer edge of residential areas in Calgary, with the outer communities being more industrial or under-developed currently.

A third adjustment to the data was made to compare senior growth versus non-senior growth. This meant that naturally communities would grow and therefore a growth in senior population was expected. Therefore, the responding variable changed to become the difference between senior population growth and general population growth. This now showed which communities

has a standardized senior population growth at a higher rate than its general standardized population growth, which now indicated that this community was more appealing for seniors in comparison to younger demographics.

$$Y_{Senior\ vs\ General\ Relocation\ _{Community}} = \frac{(x_{\Delta\ Seniors_{Community}} - x_{\Delta\ General_{Community}}) - (\mu_{\Delta\ Seniors_{Community}} - \mu_{\Delta\ General_{Community}})}{\sqrt{\frac{\sigma^2_{\Delta\ Seniors_{Community}}}{n_{\Delta\ Seniors_{Community}}} + \frac{\sigma^2_{\Delta\ General_{Community}}}{n_{\Delta\ General_{Community}}}}}$$

Using these two standardized response variables, resources will be compared to find causes for senior growth in a community as well as senior growth relative to the general population's growth in a community.

5) Regressions and Analysis

Multi-variate linear regressions are used. They follow the formula listed below with any modifications to variables (such as a percentage or taking the natural logarithm of the variable) will be listed before-hand.

$$Y_{Standardized\ Senior\ Relocation_{Community}} = B_0 + B_1 n_{Variable\ 1} + B_2 n_{Variable\ 2} \ldots + B_n n_{Variable\ n}$$

5a) Senior Services

The first resource that will be tested are senior services. Provincial and federal governments fund a variety of services specifically for seniors, which is further supplemented by private services. Using the senior services data [4], all senior services in Calgary have been categorized by their specialty. These services are categorized by the City of Calgary into these groups: abuse issues, death and funerals, educational programs, financial assistance and pensions, food assistance and grocery shopping, government services, health and safety, housing, legal information and assistance, recreation, respite caregivers and transportation. In total, the data consists of 433 locations where a senior service was provided in Calgary [4].

First off, the different services were grouped to their corresponding community, giving each community a frequency for each type of senior service. This number was transformed by taking its natural logarithm and then tested.

```
Coefficients:
                                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                                          0.07741    0.07015   1.103   0.2708
log1p(seniors$Seniors....Abuse.Issues)               0.06097    0.42859   0.142   0.8870
log1p(seniors$Seniors...Death.and.Funerals)          0.20850    0.37989   0.549   0.5836
log1p(seniors$Seniors...Educational.Programs)       -0.22916    0.57151  -0.401   0.6888
log1p(seniors$Seniors...Financial.Assistance.and.Pensions)  0.05136    0.40967   0.125   0.9003
log1p(seniors$Seniors...Food.Assistance.and.Grocery.Shopping) -0.05650    0.30851  -0.183   0.8548
log1p(seniors$Seniors...Government.Services)        -0.10839    0.24857  -0.436   0.6632
log1p(seniors$Seniors...Health.and.Safety)           0.14953    0.20610   0.726   0.4688
log1p(seniors$Seniors...Housing)                    -0.06959    0.18091  -0.385   0.7008
log1p(seniors$Seniors...Legal.Information.and.Assistance)  0.31471    0.35741   0.881   0.3794
log1p(seniors$Seniors...Recreation)                 -0.20468    0.47186  -0.434   0.6648
log1p(seniors$Seniors...Respite...Caregiver)        -0.46077    0.26555  -1.735   0.0838 .
log1p(seniors$Seniors...Transportation)              0.04165    0.25628   0.163   0.8710
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.005 on 271 degrees of freedom
Multiple R-squared:  0.03364,   Adjusted R-squared:  -0.009152
F-statistic: 0.7861 on 12 and 271 DF,  p-value: 0.6647
```

Figure 1: Regression showing the relation between Senior Services and Standardized Senior Growth

From Figure 1, data from 271 communities is used. None of the services seem to significant at the 95% confidence level as the P value is greater than 0.05 for every service. Respite Caregiver services, however, do have a P value of 0.0838, which is close to statistically significant, however, interesting has a negative coefficient. This would mean that seniors are less likely to relocate to a community which provides caregiver services. From this multi-variate regression, we fail to reject the null hypothesis. Therefore, it is inconclusive if the proximity of senior services significantly impact a senior moving to that community.

Further analyzing the data, and looking at economic intuition, this seems to be the expected case. Most of these services would be set up in more popular and central areas so that it can be reachable by many seniors in the surrounding areas. Also, none of these, besides the respite/caregiver service, is essential for everyday life. Therefore, a senior would not necessarily care if they are in the same community or the next community over to the senior service.

```
Coefficients:
                                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                                        -0.05396    0.07205  -0.749    0.455
log1p(seniors$Seniors....Abuse.Issues)             -0.10902    0.43425  -0.251    0.802
log1p(seniors$Seniors...Death.and.Funerals)         0.14987    0.38459   0.390    0.697
log1p(seniors$Seniors...Educational.Programs)      -0.20751    0.57893  -0.358    0.720
log1p(seniors$Seniors...Financial.Assistance.and.Pensions)    -0.37200    0.41955  -0.887    0.376
log1p(seniors$Seniors...Food.Assistance.and.Grocery.Shopping)  0.05999    0.31266   0.192    0.848
log1p(seniors$Seniors...Government.Services)        0.33217    0.25767   1.289    0.198
log1p(seniors$Seniors...Health.and.Safety)          0.02639    0.21759   0.121    0.904
log1p(seniors$Seniors...Housing)                   -0.01575    0.18398  -0.086    0.932
log1p(seniors$Seniors...Legal.Information.and.Assistance)     -0.01769    0.36170  -0.049    0.961
log1p(seniors$Seniors...Recreation)                 0.18611    0.47874   0.389    0.698
log1p(seniors$Seniors...Respite...Caregiver)        0.06590    0.26953   0.245    0.807
log1p(seniors$Seniors...Transportation)            -0.04672    0.25984  -0.180    0.857

Residual standard error: 1.016 on 262 degrees of freedom
  (9 observations deleted due to missingness)
Multiple R-squared:  0.01207,   Adjusted R-squared:  -0.03318
F-statistic: 0.2667 on 12 and 262 DF,  p-value: 0.9936
```

Figure 2: Regression showing Senior Services as a predictor for the difference between Senior Growth and General Population growth

From the seniors vs general relocation regression, it again appears that nothing is statistically significant. This means that it cannot be concluded that senior services have an impact on senior relocation in absolute terms or relative to the general public's relocation.

5b) Community Services

The next resource that will be tested are amenities and community services. Using the community services data [5], all community services in Calgary have been categorized by their specialty. These services are categorized by the City of Calgary into these groups: city attractions, hospitals, libraries, health clinics, community centres and social development centres. Specifically, hospitals and health clinics are of interest to this project, as the initial hypothesis was that seniors would be more likely to relocate to these areas since they have a higher demand for medical treatment and services. In total, the data consists of 202 locations where a community service was provided in Calgary including 5 hospitals and 9 health clinics [5].

To test if senior relocation is affected by any community service, a logarithmic multi-variable regression will be conducted. Therefore, the null and alternative hypothesis are listed below.

First off, the different services were grouped to their corresponding community, giving each community a frequency for each type of senior service. This number was transformed by taking its natural logarithm and then tested.

```
Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  -0.03548    0.07545  -0.470   0.6385
log1p(seniors$Attraction)    -0.44050    0.24712  -1.783   0.0758
log1p(seniors$Hospital)       0.16889    0.65705   0.257   0.7973
log1p(seniors$Library)        0.06428    0.40150   0.160   0.8729
log1p(seniors$PHS_Clinic)     0.35598    0.55683   0.639   0.5232
log1p(seniors$Community_Centre) 0.22691  0.18344   1.237   0.2171
log1p(seniors$Social._Dev_Ctr) -0.57176  0.67164  -0.851   0.3953
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1 on 277 degrees of freedom
Multiple R-squared:  0.02074,   Adjusted R-squared:  -0.0004757
F-statistic: 0.9776 on 6 and 277 DF,  p-value: 0.4407
```

Figure 3: Regression showing Community Services as a predictor for Standardized Senior Growth

From the regression, it is apparent that these variables are not significant predictors for senior relocation for the 277 applicable communities. None of the services seem to significant at the 95% confidence level as the P value is greater than 0.05 for every service. From this multi-variate regression, we fail to reject the null hypothesis. Therefore, it is inconclusive if the proximity of senior services significantly impact a senior moving to that community.

Hospitals and PHS clinics would be placed in more central locations to improve accessibility, but both have low t-values and high P-values, indicating that their impact on senior relocation cannot be concluded. Besides those two services, the other services wouldn't necessarily be too crucial to put in central areas, but they too appear to have no impact on senior relocation. This is expected though as very few individuals would factor in the proximity of a library, community centre or social development centre when moving houses. Interestingly, attractions in a community are close to statistically significant, and actually have a negative relationship with senior relocation. This means that seniors are more likely to move away from communities with attractions. A possible reason for this could be that these attractions would lead to a higher amount of traffic and noise, which are undesirable in a new house.

```
Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  -0.14907    0.07663  -1.945  0.05278 .
log1p(seniors$Attraction)     0.38594    0.24468   1.577  0.11590
log1p(seniors$Hospital)       0.39401    0.65018   0.606  0.54503
log1p(seniors$Library)       -0.39471    0.39724  -0.994  0.32129
log1p(seniors$PHS_Clinic)     0.31837    0.55083   0.578  0.56376
log1p(seniors$Community_Centre)  0.52067    0.18295   2.846  0.00477 **
log1p(seniors$Social._Dev_Ctr)   0.19968    0.66441   0.301  0.76400
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9895 on 268 degrees of freedom
  (9 observations deleted due to missingness)
Multiple R-squared:  0.04239,   Adjusted R-squared:  0.02095
F-statistic: 1.977 on 6 and 268 DF,  p-value: 0.06912
```

Figure 4: Regression showing Community Services as a predictor for the differences in senior vs general pop growth

From the regression comparing senior relocation to the general public, it seems that attractions appear to have a positive correlation with the response variable. While this isn't statistically significant in a 95% confidence interval, this means that seniors are more likely to move to a community which contains an attraction as opposed to the general public. However, when combining the results with the earlier regression, it can be inferred that neither group likes living in a community with attractions, but younger generations are less tolerant than seniors. This means that seniors are less likely to move away if already living in an area with attractions as opposed to younger generations.

Furthermore, the second regression shows that the presence of community centres are statistically significant when comparing senior relocation to the general public. As the coefficient is positive in this regression, this means that seniors are more willing to live in a community with a community centre in comparison to younger generations. As this was not significant in the senior relocation regression indicating that seniors are indifferent to community centres in their community. This implies that younger generations are more likely to move away from a community with a community centre. Using economic intuition, this makes sense as generally communities with a community centre are older as naturally community centres require some time to be constructed. Naturally, younger generations would move to newer, developing communities for a variety of reasons, which might be what the underlying cause is for this difference in preference of community centres.

5c) Crime

The next resource that was addressed was safety. This could be derived by the number of crimes committed in the community. The data was collected by the Calgary Police Service who split the categories by type of crime and the community in which it occurred [6]. Using their data, crimes were summed up to provide a total for each community per year. Additionally, two new variables were created. The first was a percentage change of crimes between 2014 and 2016 which ideally would show areas where safety has improved or worsened over the given

period. The second was a percentage of total crimes in Calgary for the given community which ideally would show how safe the community is relative to other communities. In the regressions, the total crimes in 2016 was transformed by taking its natural log.

The reason crimes were tested was due to the assumption that seniors are more susceptible to being a crime victim and therefore might be more resistant than younger generations to crime-ridden neighborhoods.

```
Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)
(Intercept)                        -1.10551    0.33876  -3.263  0.00127 **
log1p(crime_seniors$Crimes_2016)    0.21663    0.06415   3.377  0.00086 ***
crime_seniors$Percent_Change_Crime  0.01886    0.05895   0.320  0.74934
crime_seniors$Percent_Total_Crime_2016 -18.34010   12.35480  -1.484  0.13905
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9485 on 231 degrees of freedom
Multiple R-squared:  0.04955,   Adjusted R-squared:  0.0372
F-statistic: 4.014 on 3 and 231 DF,  p-value: 0.008238
```

Figure 5: Regression showing Crime data as a predictor for Senior Relocation

The senior relocation regression is intriguing as the number of crimes in 2016 are statistically significant to senior relocation, but surprisingly there is a positive correlation. Given that this does include 231 communities in the relationship, this seem counter-intuitive as it is illogical to assume that seniors would want to relocate to areas with higher crime rates. The most logical explanation is that there are some other major values that a given community provides which leads to a senior relocating there, and those same values might be what is most appealing for criminals to commit crime there.

```
Coefficients:
                                   Estimate Std. Error t value Pr(>|t|)
(Intercept)                         0.23781    0.37146   0.640    0.523
log1p(crime_seniors$Crimes_2016)   -0.02600    0.07027  -0.370    0.712
crime_seniors$Percent_Change_Crime -0.34798    0.06391  -5.445 1.33e-07 ***
crime_seniors$Percent_Total_Crime_2016  3.02728   13.38433   0.226    0.821
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.025 on 230 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.1152,    Adjusted R-squared:  0.1037
F-statistic: 9.985 on 3 and 230 DF,  p-value: 3.269e-06
```

Figure 6: Regression showing crime data as a predictor for the differences between senior growth and general population growth in a community

The senior vs general public relocation shows a different aspect of the situation. In this regression, 230 communities show that the percentage change in crime in each community negatively impacts senior vs general public relocation. This relation is statistically significant as

its P value is lower than 0.025 and its t-value is greater than 1.96. It is expected to be a negative correlation as an increase in crime rates over time indicates a neighborhood that has become less safe, and therefore is less desired for relocation. Based on the first regression, it is inconclusive how seniors react to a growing crime rate. Therefore, from the second regression, it appears that the general public are more likely to move away from communities with increasing crime, or to communities with decreasing crime in comparison to seniors. From the perspective of seniors, this means that they are more likely to remain in areas with increasing crime, and are less likely to move to safer areas in comparison to the general public.

5d) Transportation

Transportation is a key resource that can influence an individual's housing decisions. This is especially important as seniors can personally be more resistant to driving as they age and may even legally lose driving privileges due to medical conditions. Therefore, having readily accessible public transportation could be crucial for a senior's mobility. Calgary provides various public bus routes as well as a light transit rail (LRT) which connects most of the city. Unfortunately, there data regarding bus stations isn't available, however, the locations of LRT stations are. This data was collected from Open Calgary and provides information for all 47 LRT stations in the city [7].

This dataset, however, does not provide a community code like the other datasets, but does provide geographic coordinates of every single station [7]. Therefore, extrapolated variables were created in order to create a relation between the LRT stations and communities. This was done by using the "Community Points" dataset which provides a centroid geographic coordinate for every community [8]. Using the middle point of every community, a dummy variable was created for the number of LRT stations that were in a 1km radius of this point, and another for a 2km radius. This was derived from taking the coordinates of the centroid and adding a measurement interval to the latitude and longitude, and then using the LRT station coordinates if it fell into this interval. With Calgary being at a latitude of 51° N, this meant that a 1km radius equivalent would be ±0.0142° for the longitude coordinate, and ±0.0899° for the latitude coordinate [9].

```
Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                    0.04331    0.07165   0.604    0.546
log1p(seniors$LRT_1km_radius) -0.08363    0.20463  -0.409    0.683
log1p(seniors$LRT_2km_radius) -0.06076    0.11477  -0.529    0.597

Residual standard error: 1.001 on 281 degrees of freedom
Multiple R-squared:  0.005172,  Adjusted R-squared:  -0.001909
F-statistic: 0.7304 on 2 and 281 DF,  p-value: 0.4826
```

Figure 7: Regression showing LRT stations as a predictor for standardized senior growth in a community

```
Coefficients:
                             Estimate Std. Error t value Pr(>|t|)
(Intercept)                 -0.07191    0.07291  -0.986   0.3249
log1p(seniors$LRT_1km_radius) -0.21394    0.20406  -1.048   0.2954
log1p(seniors$LRT_2km_radius)  0.21841    0.11490   1.901   0.0584 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9968 on 272 degrees of freedom
  (9 observations deleted due to missingness)
Multiple R-squared:  0.01364,   Adjusted R-squared:  0.006389
F-statistic: 1.881 on 2 and 272 DF,  p-value: 0.1544
```

Figure 8: Regression showing LRT data as a predictor for the difference between senior growth vs general growth of a community

From the first regression, it is apparent that having an LRT station in a 1 or 2km radius does not significantly factor into a seniors housing choice. From the second regression showing how LRT stations relate to the difference in senior relocation vs general public relocation, having an LRT station within 2km of the is almost statistically significant with a t-value of 1.901 and a P-value of 0.0584. With the coefficient being positive, this indicates that seniors are more likely to choose a community with more LRT stations in a 2km radius of its centroid as opposed to younger generations. However, given that this is a two-tailed test, a P-value of 0.025 is required, and therefore we must fail to reject that LRT stations have an impact on senior relocation as well as senior relocation in relation to younger generations.

Having panel data to indicate exactly how far a person lives from an LRT station would have been more effective in showing a relationship in comparison to the dummy variables created. Also, incorporating bus stations would be incredibly useful as that large component of public transportation is being omitted here due to lack of data.

5e) Economic Characteristics of a Community

One aspect of a community that can foster or deter relocation to it is its economic makeup. Areas with higher levels of employment can indicate the community's socio-economic class and lifestyle habits which can influence an individual's housing decisions. Another aspect of its economic makeup is the number of businesses that are located within the community. Having access to grocery stores, strip malls, and other products and services in close proximity boost an individual's preference to live in that community.

The City of Calgary provides data regarding Business Licenses, the year the business started, and the community where it is located [10]. This dataset includes 30,153 different businesses that have officially been registered with the City of Calgary as of 2016 [10]. A new variable, Percentage of Businesses created in 2016 was created by dividing the number of businesses created in 2016 by the total number of businesses in each community. In total 2828 businesses were registered in 2016 making the average Percentage of Business created in Calgary 9.37% [10]. The natural logarithm of the number of business licenses and the percentage of new business licenses were used in the regression.

Data regarding the number of employed residents from each community was included in the 2016 census, but not the 2014 census [11] [12]. A new variable for Employment % was created by dividing the

number of employees by the number of residents per community. In 2016, 596,883 residents were employed city-wide[12]. The natural log of the employment percentage was used in the regression.

```
Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                      1.15447    0.65581   1.760  0.07976 .
log1p(seniors$EMPLYD_PCT)        1.13121    0.43338   2.610  0.00969 **
log1p(seniors$Business_Licenses) -0.05647    0.05758  -0.981  0.32785
seniors$BL_new_2016_pct          1.31129    0.63883   2.053  0.04132 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.085 on 215 degrees of freedom
  (65 observations deleted due to missingness)
Multiple R-squared:  0.05556,   Adjusted R-squared:  0.04238
F-statistic: 4.216 on 3 and 215 DF,  p-value: 0.006371
```

Figure 9: Regression showing economic characteristics as a predictor for standardized senior growth in a community

```
Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                   -2.58353    0.61911  -4.173 4.39e-05 ***
log1p(seniors$EMPLYD_PCT)     -0.66510    0.41021  -1.621    0.106
log1p(seniors$Business_Licenses)  0.01920    0.05577   0.344    0.731
seniors$BL_new_2016_pct       -3.02588    0.60429  -5.007 1.16e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.023 on 211 degrees of freedom
  (69 observations deleted due to missingness)
Multiple R-squared:  0.115,     Adjusted R-squared:  0.1024
F-statistic: 9.136 on 3 and 211 DF,  p-value: 1.036e-05
```

Figure 10: Regression showing economic characteristics as a predictor for the differences between senior vs general population growth in a community

From the first regression, the employment % and new business license % were both significant in predicting senior relocation. Using data from 216 communities, these predictors had a positive relationship with t-values above 1.96, but only employment % had a P-value below 0.025. It appears from this that areas with higher employment percentages affect a senior’s decision to relocate there. Therefore, we reject the hypothesis that socio-economic makeup of a community has no impact on senior relocation.

From the second regression, the percentage of new Business licenses seems to be statistically significant with an extremely low P-value and a t-value lower than -5 through the analysis of 211 different communities. As this is a negative correlation, this means that if a community has a higher number of new businesses and is growing, it is more likely to cause general public’s relocation there in comparison to senior relocation. From the first regression, it seems that seniors are positively influenced by new businesses in their relocation preference, but are less influenced by it in comparison to younger generations. Therefore, we fail to reject the hypothesis that economic makeup of community has no impact on senior relocation in relation to general relocation.

5f) House Characteristics

Types of housing available is a big factor in affecting housing decisions for seniors and the general public. Some of these factors include the house's price, owning vs renting, type of house, and number of residents per house. This closely ties in with Pastalan's work as noted in the Previous Research section, which found that seniors prefer owning a house as opposed to renting. The data was collected from City of Calgary's community censuses in 2014 and 2016 which had the number of dwellings, types of dwelling, number of dwellings owned by the resident, and number of residents per dwelling [11] [12]. The median assessed value of houses per community was also provided by the City of Calgary in a separate dataset [13].

Using this data, a variety of new variables were created for testing changes in a community's characteristics. New_houses is a variable displaying the number of new dwellings in a community from 2014 to 2016. The number of renters was derived by the difference between the number of homeowners and number of residents per community. Using the 2014 and 2016 values, a change in the number of renters was found, which is one of the variables used in the regression. A percentage of homeowners was derived to show which communities had a higher preference to owning vs renting. The 2014 to 2016 change in number of nursing homes and the number of dwellings categorized by number of residents was also calculated for every community. Do note that dwellings categorized by the number of residents was done by the City of Calgary and therefore they are in categories of 1 resident, 2 residents, 3 residents, 4 or 5 residents and 6+ residents.

```
Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                   1.741e-01  2.853e-01   0.610   0.5424
New_houses                   -1.735e-04  1.177e-03  -0.147   0.8830
seniors$Median.assessed.value -5.821e-07  2.676e-07  -2.175   0.0310 *
seniors$renting_act_chg       3.235e-04  9.841e-04   0.329   0.7428
seniors$Homeowners_pct        8.633e-01  9.828e-01   0.878   0.3810
seniors$new_nursing_hm        5.857e-01  2.035e-01   2.879   0.0045 **
seniors$chg_dwell_1           3.984e-03  9.843e-04   4.048 7.81e-05 ***
seniors$chg_dwell_2           1.989e-03  1.551e-03   1.282   0.2015
seniors$chg_dwell_3           9.053e-04  1.890e-03   0.479   0.6325
seniors$chg_dwell_4_5        -3.085e-04  1.560e-03  -0.198   0.8435
seniors$chg_dwell_6           7.873e-03  5.609e-03   1.404   0.1623
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.8451 on 172 degrees of freedom
  (101 observations deleted due to missingness)
Multiple R-squared:  0.3604,    Adjusted R-squared:  0.3232
F-statistic: 9.691 on 10 and 172 DF,  p-value: 9.548e-13
```

Figure 11: Regression showing Housing Characteristics as a predictor for standardized senior relocation to a community

From the regressions, only 172 communities were used. This appears to be because some communities are missing data for the median assessed value variable. Besides that, the regressions were extremely successful considering that there are statistically significant variables and higher R^2 values than other factors.

The first regression shows that new nursing homes and the change in dwellings for 1 resident is statistically significant for a two-tailed test at the 95% confidence level. These variables are t-values greater than 1.96, P-values lower than 0.025 and positive coefficients. This means that if there is an increase in the number of nursing homes or single resident dwellings in a community, there will be a significant number of seniors moving there. This does seem to make sense as nursing homes of course are designed to house seniors who require additional care, and single dwellings would be appealing to widows and widowers. Given the magnitudes of the coefficients, it appears that increases in nursing homes is a much more significant predictor than increases in single resident dwellings. 2014 had 71 nursing homes in Calgary, and which surprisingly was the same as 2016 [11] [12]. However, certain nursing homes were discontinued while others were added in new communities which explains its significance in explaining senior relocation. Median assessed value would have been significant at a 90% confidence level in the regression.

The coefficient is negative indicating that seniors would actually prefer to relocate to neighborhoods with lower house values, which might be due to seniors retiring. As seniors retire, their cash inflow decreases, which naturally means that costs and expenses must decrease. This would provide evidence that their cash inflows through savings, pensions, RESPS and government programs is significantly lower than pre-retirement, meaning that they must move to a lower utility level. However, the coefficient is extremely small in relation to the coefficients of other variables, indicating that this impact is minimal.

Contrary to Pastalan's findings in his paper as outlined in the Background Research, the regression finds that the effect or owning a house as opposed to renting does not significantly impact senior's relocation preferences. This can be seen as the % of Homeowners per community variable is not statistically significant. Even though there is a significantly greater coefficient for Homeowner % in comparison to other variables, the effect of communities were owning a house is higher is inconclusive in relation to senior relocation.

Overall, we reject the hypothesis that senior relocation is not affected by the housing characteristics of a community. New nursing homes and single resident dwellings appear to attract seniors to these communities at a 95% significance level.

```
Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                   2.286e-01  6.421e-02   3.561 0.000478 ***
New_houses                   -1.425e-03  2.650e-04  -5.378 2.43e-07 ***
seniors$Median.assessed.value -1.030e-07  6.022e-08  -1.711 0.088840 .
seniors$renting_act_chg       1.356e-03  2.215e-04   6.123 6.05e-09 ***
seniors$Homeowners_pct        2.237e-01  2.212e-01   1.011 0.313236
seniors$new_nursing_hm        5.499e-02  4.579e-02   1.201 0.231461
seniors$chg_dwell_1          -2.682e-04  2.215e-04  -1.211 0.227706
seniors$chg_dwell_2          -1.949e-03  3.492e-04  -5.583 9.08e-08 ***
seniors$chg_dwell_3          -4.314e-03  4.254e-04 -10.141  < 2e-16 ***
seniors$chg_dwell_4_5        -5.909e-03  3.512e-04 -16.827  < 2e-16 ***
seniors$chg_dwell_6          -8.436e-03  1.263e-03  -6.682 3.15e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.1902 on 172 degrees of freedom
  (101 observations deleted due to missingness)
Multiple R-squared:  0.9768,    Adjusted R-squared:  0.9755
F-statistic: 725.6 on 10 and 172 DF,  p-value: < 2.2e-16
```

Figure 12: Regression showing housing characteristics as a predictor for the difference between senior and general population growth in a community

The second regression has many statistically significant data at the 95% significance level and an adjusted R^2 of 0.9755 for 172 communities. The number of new houses, number of new rented houses, number of new dwellings for more than 2 residents all appear to be statistically significant in predicting the difference between senior relocation versus general public's relocation. All of these variables have a t-values greater than 1.96,P-values less than 0.025 and negative coefficients except for the change in rented houses. This means that an increase in the number of rented houses in a community leads to a higher rate of seniors relocating to the community in comparison to the general public, or potentially the general public moving away from these areas. The negative coefficients for new houses and new houses with 2 or more residents seems to indicate that growing neighborhoods seem to primarily attract the general public at a much higher rate than seniors. Given that the first regression showed that the impact of new houses had no statistically significant impact on senior relocation, this means that the negative relationship in this regression is due to these developing communities being very attractive for younger generations. At the 95% significance level, we reject the null hypothesis that housing characteristics of a community do not have any impact on the relative difference between senior relocation and the general public's.

The economic reasoning behind seniors seeming to prefer rented houses at a higher rate than the general public is two-fold. One aspect of it is that seniors could prefer rented houses more due to renting being a more risk-averse strategy in case of housing market crashes as outlined in the Financial Post's article "Why Older Seniors Should Rent instead of Buy" [14]. The article also includes that in case the senior needs to relocate again due to health concerns, selling a house can become time-consuming and a burden [14]. Based on the first regression though, the

positive difference between senior relocation versus younger generation's doesn't appear to be significant from the senior's side, which indicates that it is most likely due to a change in younger generation's. Theoretically, younger generations would relocate in order to own their own homes if looking for a long-term solution which might be causing a higher preference for communities with more homeowners as opposed to renters.

From the first regression, an increase in nursing homes and single resident dwellings had a positive impact on senior relocation to the community. Based on this regression, while the affect of new nursing homes heavily influences senior relocation in comparison to younger generation's relocation, it is not statistically significant. The change in single resident dwellings is also not statistically significant, but also has a negative coefficient. This means that based on the first regression which showed that seniors were positively influenced by single resident dwellings in a community, the influence is much less than the influence it has on younger generations.

The R^2 of 0.9768 and adjusted R^2 of 0.9755 indicates an almost perfect fit for explaining the variances. This at first might seem erroneous because naturally communities with an increased number of houses would lead to an increased population. However, considering that the response variable is the difference between growth rates of seniors versus younger generation, this provides an interesting theory. Almost all the differences between growth rates between seniors and non-seniors in a community can be defined by whether a community has increased its number of houses. This means that developing communities are primarily filled with younger generations and that seniors primarily move to already established communities. While this may have been predicted as developing communities are more appealing to younger families who are looking for a long-term home, it is now backed up with data.

5g) Final Regressions

For the final regression, statistically significant variables from the various resource regressions were used to create a final model. First, they were all run in one regression, and then certain variables were removed if they had a high multi-collinearity. Multi-collinearity was tested using a Variance Inflation Factors (VIF) test and these results can be seen below.

```
seniors$Seniors...Respite...Caregiver          seniors$Attraction                 seniors$Hospital
                             1.038958                    2.300610                        1.161238
            seniors$Community_Centre                seniors$Crimes_2016 seniors$Percent_Change_Crime
                             1.538639                    4.146235                        1.414915
                  seniors$EMPLYD_PCT            seniors$BL_new_2016_pct       seniors$new_nursing_hm
                             1.481218                    1.304657                        1.122239
                 seniors$chg_dwell_1                seniors$chg_dwell_2           seniors$chg_dwell_3
                             2.698799                    6.153834                        2.542297
               seniors$chg_dwell_4_5                seniors$chg_dwell_6            seniors$New_houses
                             4.957930                    2.223135                       41.428536
            seniors$renting_act_chg
                            10.510417
> |
```

Figure 13: VIF Test for Significant variables for predicting Standardized Senior Growth

```
seniors$Seniors...Respite...Caregiver                 seniors$Attraction                    seniors$Hospital
                             1.088609                           2.496269                           1.227140
            seniors$Community_Centre                seniors$Crimes_2016  seniors$Percent_Change_Crime
                             1.323693                           4.981101                           1.663609
                 seniors$EMPLYD_PCT              seniors$BL_new_2016_pct  seniors$Median.assessed.value
                             1.330128                           1.346241                           1.385040
               seniors$new_nursing_hm                 seniors$chg_dwell_1                seniors$chg_dwell_2
                             1.156410                           2.871628                           6.341920
                  seniors$chg_dwell_3                seniors$chg_dwell_4_5                seniors$chg_dwell_6
                             2.573651                           5.225181                           2.204762
                   seniors$New_houses              seniors$renting_act_chg
                            43.585170                          11.032638
```

Figure 14: VIF Test for significant variables for predicting the differences between Senior and General Population growth in communities

```
Coefficients:
                                        Estimate Std. Error t value Pr(>|t|)
(Intercept)                            4.277e-01  4.822e-01   0.887  0.37635
seniors$Seniors...Respite...Caregiver -2.915e-01  1.565e-01  -1.862  0.06424 .
seniors$EMPLYD_PCT                     3.410e-02  8.446e-01   0.040  0.96784
seniors$Median.assessed.value         -5.188e-07  2.660e-07  -1.951  0.05269 .
seniors$new_nursing_hm                 5.802e-01  2.017e-01   2.876  0.00452 **
seniors$chg_dwell_1                    4.929e-03  8.243e-04   5.979 1.22e-08 ***
seniors$chg_dwell_6                    8.940e-03  4.086e-03   2.188  0.02998 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8503 on 176 degrees of freedom
  (101 observations deleted due to missingness)
Multiple R-squared:  0.3374,    Adjusted R-squared:  0.3148
F-statistic: 14.94 on 6 and 176 DF,  p-value: 8.835e-14
```

Figure 15: Final multi-variate regression for predicting Standardized Senior Growth in communities

From the first regression, it appears that changes in nursing homes and changes in dwellings for either 1 resident or 6 or more residents were statistically significant at the 95% significance level as their t-values were greater than 1.96 and P-values were lower than 0.025. They all have positive coefficients indicating that an increase in each variable increases the senior growth rate of that community. Median assessed value and number of respite/caregivers per community both have negative coefficients and t-values, but are not statistically significant at the 95% significance level. This regression included 176 communities in Calgary and has a R^2 of 0.3374 and adjusted R^2 of 0.3148. There is very low multi-collinearity between these variables as they all have VIFs between 1.04 and 1.13.

```
Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)             0.1905976  0.0141465  13.473   <2e-16 ***
seniors$chg_dwell_2    -0.0029969  0.0002042 -14.675   <2e-16 ***
seniors$chg_dwell_3    -0.0047850  0.0003646 -13.124   <2e-16 ***
seniors$chg_dwell_4_5  -0.0074941  0.0003112 -24.078   <2e-16 ***
seniors$chg_dwell_6    -0.0112350  0.0012588  -8.925   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2214 on 270 degrees of freedom
  (9 observations deleted due to missingness)
Multiple R-squared:  0.9517,    Adjusted R-squared:  0.951
F-statistic:  1330 on 4 and 270 DF,  p-value: < 2.2e-16
```

Figure 16: Final multi-variate regression for predicting the differences between Senior growth relative to General Population growth in a community

This regression was very similar to the regression in the housing section as these variables proved to be the most significant. It appears that changes in the number of dwellings built for 2 or more residents were statistically significant at the 95% significance level as their t-values were greater than 1.96 and P-values were lower than 0.025. They all have negative coefficients indicating that an increase in each variable decreases the senior growth rate of that community relative to it’s general growth. This regression includes 270 communities in Calgary and has a R^2 of 0.9517 and adjusted R^2 of 0.951. There is very low multi-collinearity between these variables as they all have VIFs between 1.63 and 2.80.

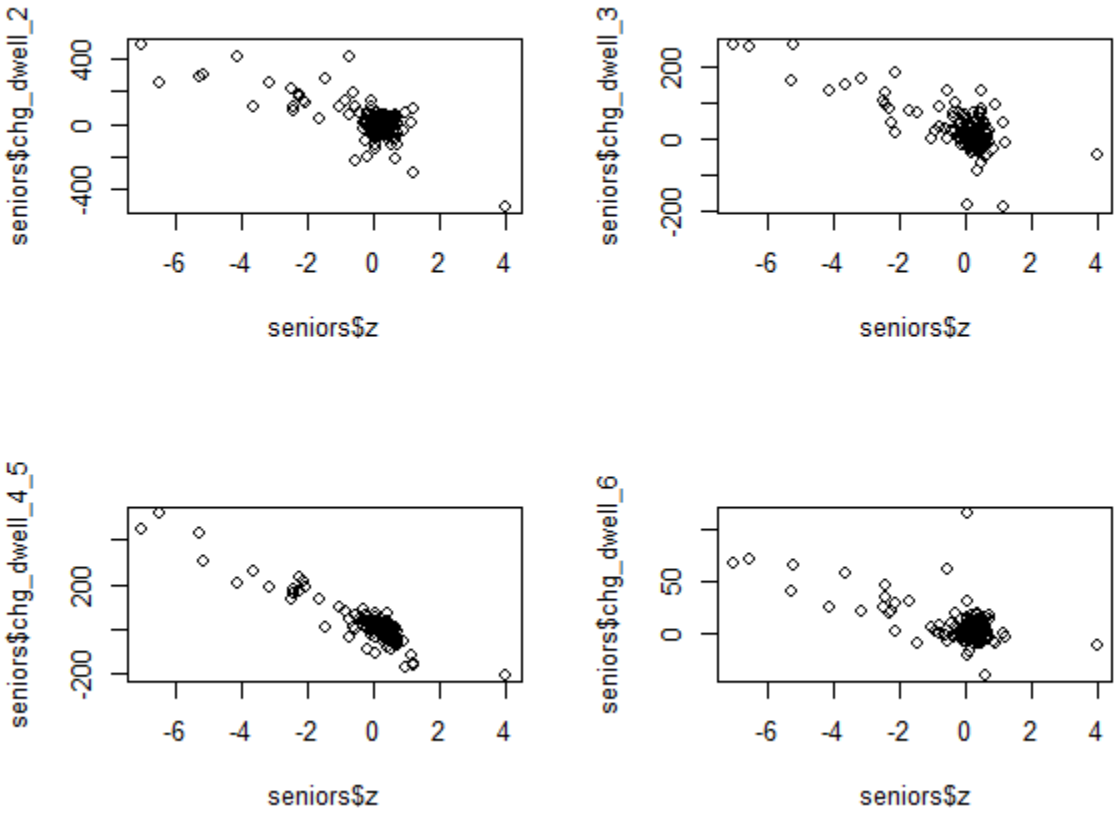


Figure 17: Shows the relationship between changes in dwelling size categorized by number of residents with the difference between Senior and General Population growth

6) Economic Benefits

Through this study, there can be a variety of derived benefits. It is apparent that new, developing communities are have a significantly higher number of non-seniors moving there in comparison to seniors. This can be useful for governments as they do not need to add the same number of government programs to areas with new communities as their demand for them there will be significantly lower than established areas. This is also beneficial for the private sector, as many businesses want to maximize their client base and outreach. For companies that are tailored towards seniors such as private homecare assistance, this can be crucial information. The allure of new communities might be tempting for a business to expand its own client base, but the projected client base of seniors will be lower in the near future as opposed to developed areas. These companies and the government instead should target areas with new nursing homes to maximize their effectiveness.

7) Conclusion

In conclusion, senior relocation is fairly difficult to predict, with the major predictor being nursing homes for senior growth in a community in Calgary. Relative to the general public, seniors are much less likely to move to new, developing areas with new dwellings being created 2 or more residents.

8) Further Improvements

One major improvement to the effectiveness of this study would be access to panel data. This would allow for exact data per individual as opposed to summary statistics per community. Having panel data would also allow the testing of other variables such as how the individual's income can affect housing decisions. This was mimicked through the median assessed value variable, but obviously lacked a certain degree of accuracy. Furthermore, panel data would be able to distinguish how many seniors are retired as opposed to still working. The two assumptions would also be solved through panel data as it would be possible to tell exactly how many people have aged into the senior's category versus how many new seniors have moved to a certain area.

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