



UNDERSTANDING WORKFORCE HOUSING:

A Study on Commuting Burden Regarding Demographic Characteristics in Metro Vancouver

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1.0 Introduction

Promoting social equality in transportation has become a key concern in building an inclusive city (Lucas and Jones, 2012). Commuting refers to the process that workers travel from a place of residence to a place of employment. Studies indicate that commute is the negotiation with some social-demographic characteristics such as income and employment (Zhang et al., 2018). However, commuting also implies a negative cost that affects workers' quality of life, as it consumes personal resources, specifically time, money, and energy for daily activities (Novaco & Milanese, 1990; Ong & Blumenberg, 1998). The phenomenon that commuting affects people's quality of life is called commuting burden, which is generally measured in terms of commuting distance, time and expenditure (Dai et al., 2016; Khattak et al., 2000).

Over the past years, considerable attention has been paid to the dramatic increase in commuting burdens in metropolitan areas in North America (Marion & Horner, 2007, Eliasson et al., 2003). Studies have shown that the unequal distribution of commuting burdens among workers diminishes people's well-being, as excessive commuting time and costs limit the time and expenses workers spend on other activities (Preston & Raje, 2007; Church et al., 2000). Disproportionate commuting burdens due to long and costly commutes restricts individuals' access to a variety of occupations/industries, thereby generating transportation inequality at the individual level (Dai et al., 2016).

Research shows that there are various explanations for the varied commuting time choices made by individuals. Alonso-type models formalize individual choices as a trade-off by proceeding housing location choices and the commuting time as predictable and rational behavior (Alonso, 1964). These models assume that the affluent can afford the commuting costs and that they prefer to live in suburban areas because they are larger (Alonso, 1964). Similarly, these models also assume that the poor choose to live close to jobs by consuming less areas to decrease the recurring commuting costs (Alonso, 1964).

Researchers who focus on social justice issues in cities mention that commuting burdens indicate social inequalities and constrained choices. Kain originally came up with the concept of spatial mismatch in response to the difficulty of predicting blacks' location decisions (Kain, 2004). Spatial mismatch studies clarify the role of racial discrimination in housing market, these studies treat housing location as an important determinant of employment outcomes (Sultana, 2005; Ihlanfeldt, 2004; Zax & Kain, 1996). The spatial mismatch hypothesis explains that the poor urban living areas provide few job locations, which further indicates why the poor have longer commutes.

With the continuous differentiation of social classes, the number of moderate-income groups increases rapidly, they are having a greater influence on the in metropolitan cities (Dai et al., 2016). However, related studies have mainly focused on residents of cities, specific occupational groups and special vulnerable groups while lending less attention to the moderate-income groups. This paper thus studies the spatial relationships between employment industry, mode of commute, duration/ distance of commute, visible minority status, and household employment income of the full-time

workers in Metro Vancouver. The study starts with a higher-level analysis based on the collected data to explore the disproportionate commuting burdens experienced by Metro Vancouver workers. Then, a series of static and interactive maps on a census tract level are produced to identify the employment centres where workers' characteristics are correlated with disproportionate commuting burdens.

2.0 Data & Methods

2.1 Data:

The analysis is concerned with the census tract level data in Metro Vancouver, it uses a custom 2016 Canadian census data from Statistics Canada, combined with a series of census dimensions as follows:

- a. Household employment income
- b. Industry/Occupation
- c. Mode of commute
- d. Duration of commute
- e. Visible minority

The original dataset contains 5 census dimensions for the 478 census tracts in Metro Vancouver. Only full-time workers who lived in rented housing and worked at least 40 weeks per year at a usual place of work are included in the dataset. For industry listed in the dataset, they are identified based on the North American Industry Classification System (NIAICS) 2012 and correlates within the list of COVID-19 Essential Services (British Columbia 2020). There are 53 industries in the dataset, a sample set of industries can be found in Table 1, the full set of industries can be found in Appendix 1. In table 1, the 2-digit industry is the highest-level category, the 3-digit industry is the detailed category under the 2-digit industry.

Industry - North American Industry Classification System (NAICS) 2012	Number of workers
Total	212825
11 Agriculture, forestry, fishing and hunting	1140
21 Mining, quarrying, and oil and gas extraction	535
22 Utilities	925
23 Construction	8545
236 Construction of buildings	2820
237 Heavy and civil engineering construction	855
238 Specialty trade contractors	4870
31-33 Manufacturing	16615
311 Food manufacturing	3205

Table 1: Number of workers in Metro Vancouver by industry

Table 2 shows the number of workers in Metro Vancouver by employment income, there are mainly 3 income levels, less than \$30,000 (lower-income level), \$30,000 to \$79,999 (moderate-income level), \$80,000 and above (higher-income level).

Employment income groups in 2015	Number of workers
Total	212825
Without employment income	4725
With employment income	208100
Less than \$30,000 (including loss)	51370
\$30,000 to \$79,999	125880
\$30,000 to \$39,999	34750
\$40,000 to \$49,999	33995
\$50,000 to \$59,999	25855
\$60,000 to \$69,999	18290
\$70,000 to \$79,999	12995
\$80,000 and above	30845
Median employment income (\$)	45074
Average employment income (\$)	53477

Table 2: Number of workers in Metro Vancouver by different income levels

Table 3 shows 5 commuting modes that are most commonly used in Metro Vancouver. Table 4 shows there are 5 categories for commuting duration. Table 5 shows the number of full-time workers for each visible minority.

Main mode of commuting	Number of workers
Total	212825
Driver alone	96615
2 or more persons shared the ride to work	17590
Public transit	59125
Walked	27410
Bicycle	9540
Other method	2550

Table 3: Number of workers in Metro Vancouver of commuting modes

Commuting duration	Number of workers
Total	212825
Less than 15 minutes	39665
15 to 29 minutes	75065
30 to 44 minutes	53890
45 to 59 minutes	23960
60 minutes and over	20255

Table 4: Number of workers in Metro Vancouver of commuting duration

Visible minority	Number of workers
Total	212825
Total visible minority population	78195
South Asian	15045
Chinese	16020
Black	3920
Filipino	17800
Latin American	5550
Arab	1470
Southeast Asian	4265
West Asian	4220
Korean	4140
Japanese	2735
Visible minority, n.i.e.	660
Multiple visible minorities	2375
Not a visible minority	134630

Table 5: Number of workers in Metro Vancouver of visible minorities

Though table 1-5 show the “number of workers” for the whole Metro Vancouver area, the analysis is conducted based on the 478 census tracts in Metro Vancouver instead of the whole area.

2.2 Method:

The analysis starts with a higher-level analysis to explore the commuting burdens experienced by full-time workers. R is the main tool to do the preliminary tabular data analysis, pie-charts and bar-charts are conducted to analyze the relationships between commuting duration, employment income, and commuting mode.

After the tabular data analysis, the groups that are experiencing disproportionate commuting burdens are identified. Then, a series of static and interactive maps are conducted through R to identify the employment centres and analyze the spatial characteristics of the groups that are experiencing disproportionate commuting burdens.

3.0 Tabular data analysis

3.1 Commuting Duration:

Commuting duration data are divided into five categories, which are “less than 15 minutes”, “15 to 29 minutes”, “30 to 44 minutes”, “45 to 59 minutes”, and “60 minutes and over”. Figure 1 shows the percentages for each commuting time category. There are about 19% of full-time workers spend less than 15mins, around 35% of workers spend 15-29mins on commuting, followed by 30-44mins (about 25%) commuting time category. Though there are about 80% of workers commuting less than 45 minutes to their jobs, there are still 21% of workers commuting more than 45 minutes everyday. Therefore, full-time workers who commute more than 45 minutes are experiencing more commuting burdens in Metro Vancouver.

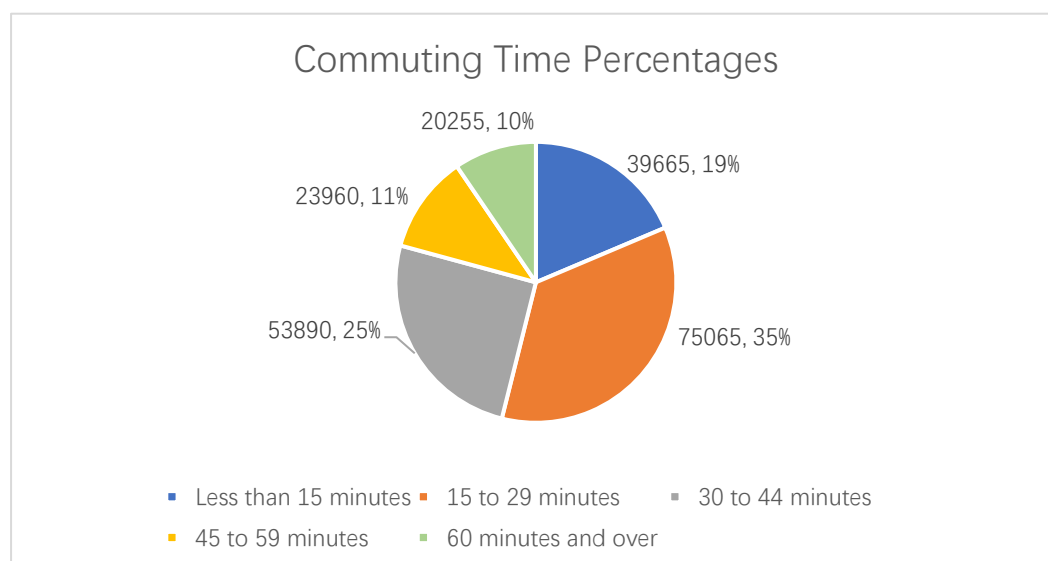


Figure 1: Commuting Duration Percentages

Note: The total number of the full-time works is 212,825.

Left number – Number of workers in each commuting duration category,
 Right number – Proportion of the total number of workers in each category;
 e.g., (20,255, 10%) – “60 minutes and over” means there are 20,255 (i.e., 10% of the total population) workers commute more than 60mins to their jobs.

3.2 Household Employment Income:

There are three categories of income data, which are “Less than \$30,000” (around 52,000 workers), “\$30,000 to \$79,999” (around 130,000 workers), “\$80,000 and above” (around 31,000 workers). Figure 2 shows the proportions of different income groups in each commuting duration category, the sum of percentages of each commuting duration category is 100%. In each commuting duration category, “\$30,000 to \$79,999” income group always has the highest proportion, because the moderate-income group has much more workers than the other two income groups.

For “Less than \$30,000” income group, relatively more workers commute “Less than 15 minutes” or “60 minutes and over”. For “\$30,000 to \$79,999” income group, workers in “45 to 59 minutes” are relatively more than other commuting duration categories. For high income group, workers commute “60 minutes and over” are obviously less than high income workers in other commuting duration categories. As moderate-income group takes around 60% of workers in each commuting duration category, further analysis will focus on moderate-income group.



Figure 2: Household Employment Income vs Commuting Duration

3.3 Commuting Mode:

There are six categories for commuting mode data, including “Driver alone”, “2 or more persons shared the ride to work”, “Public transit”, “Walked”, “Bicycle”, and “Other method”. Figure 3 is a pie chart that indicates the population and percentage of each commuting mode, where “Driver alone” (46%) is the most common commuting mode, followed with “Public transit” (28%) and “Walked” (13%).

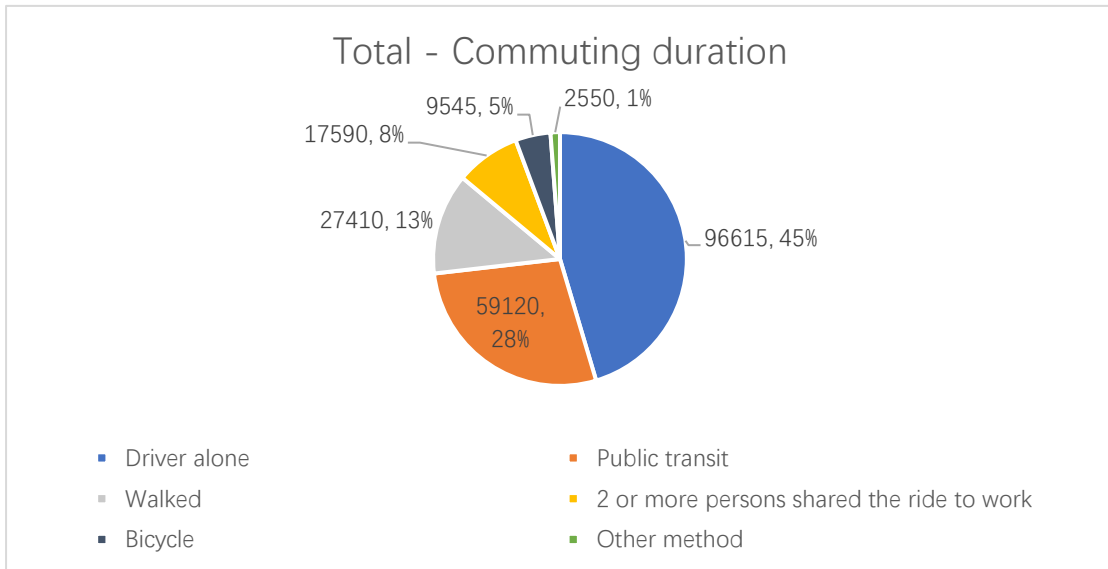


Figure 3: Commuting Mode Percentages

Note: Left number – Number of workers in each commuting mode, Right number – Proportion of the total number of workers in each category; e.g., (27,410, 13%) – “Walked” means there are 27,410 (i.e., 13% of the total workers) workers commute to their jobs by walking.

Though “Driver alone”, “Public transit” and “Walked” are the three most common commuting modes for all workers, there are obviously differences between different commuting duration categories. Figure 4-8 show the top 3 common commuting modes for each commuting duration category.

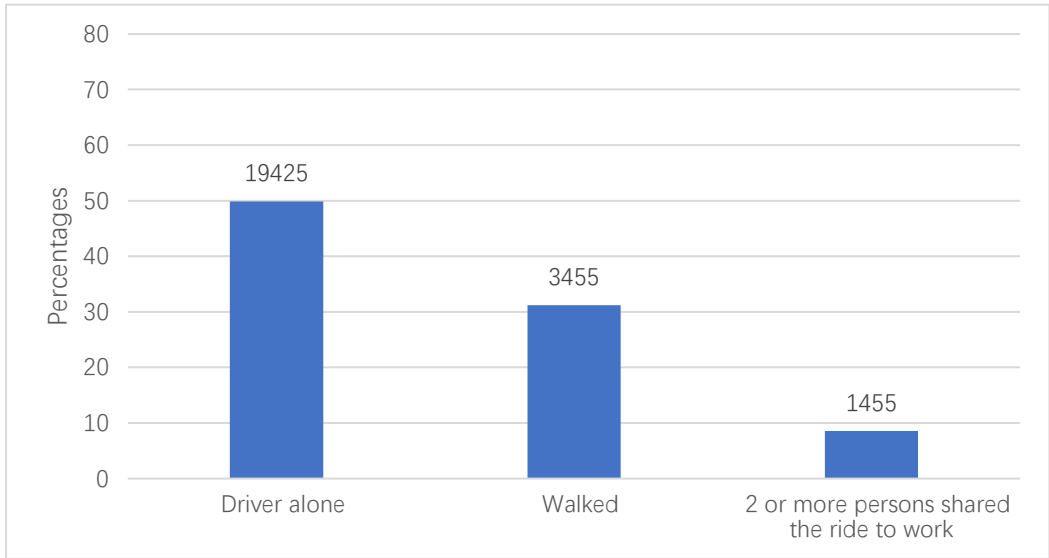


Figure 4: Top 3 Commuting Modes vs Duration (Less than 15 minutes)

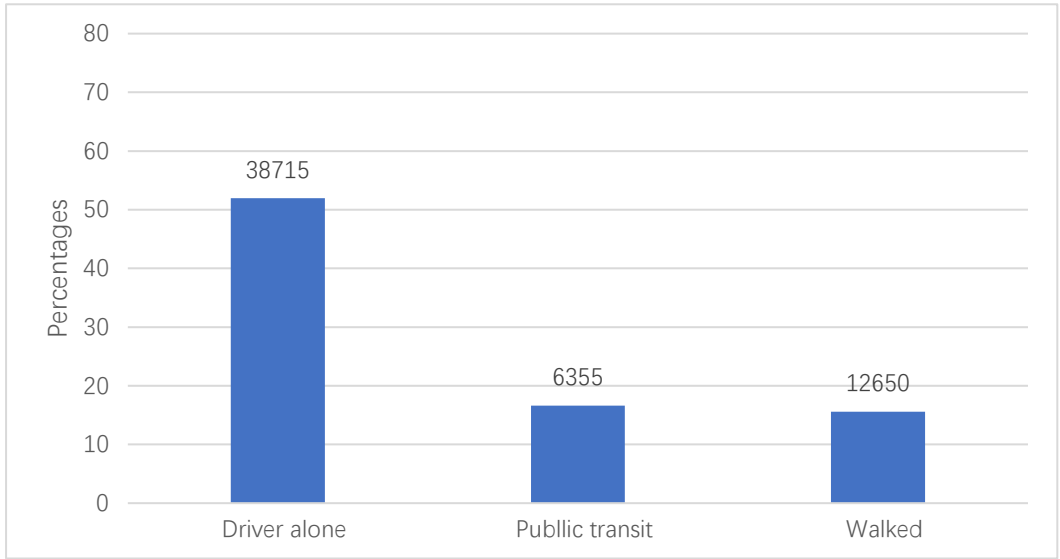


Figure 5: Top 3 Commuting Modes vs Duration (Less than 15 minutes)

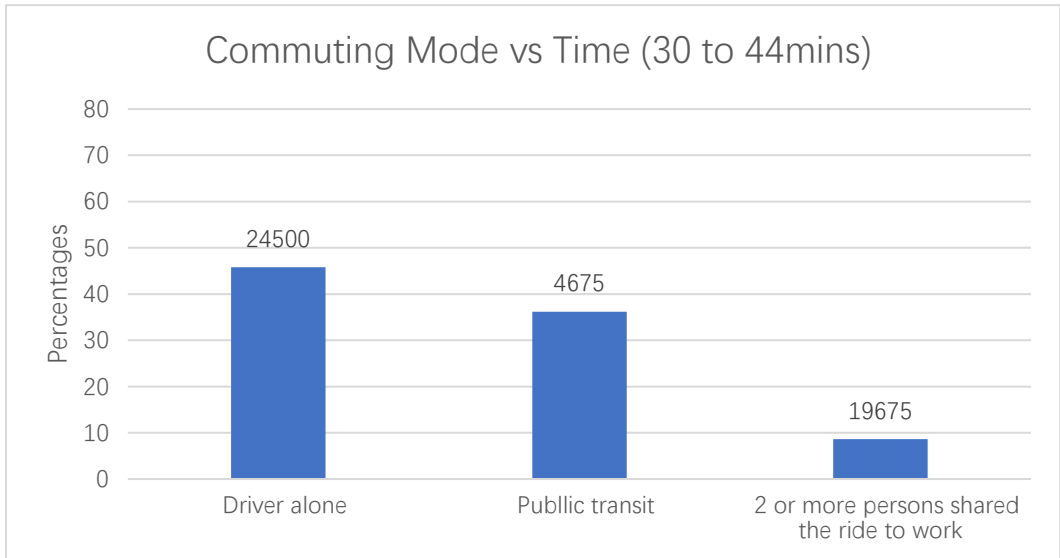


Figure 6: Top 3 Commuting Modes vs Duration (30 to 44mins)

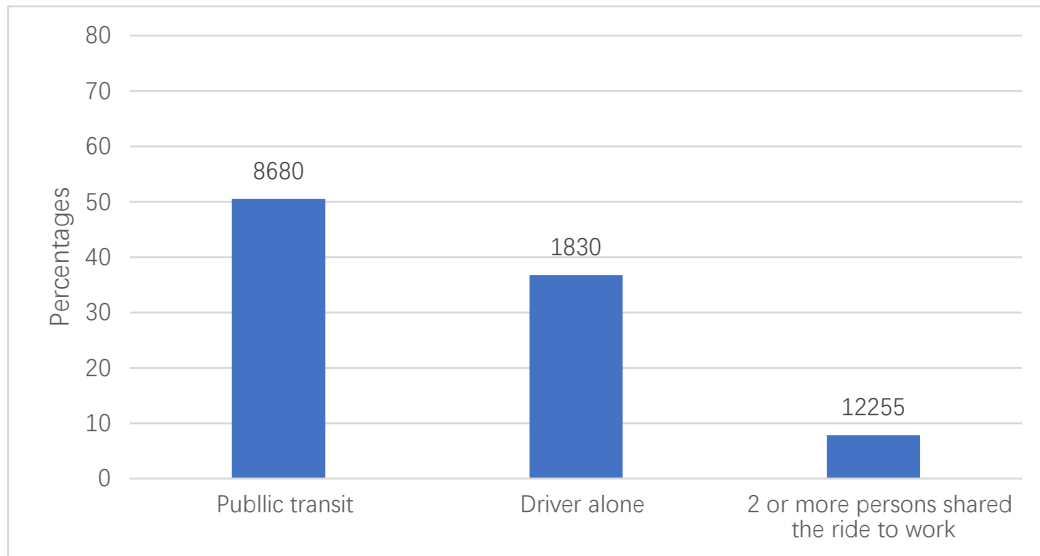


Figure 7: Top 3 Commuting Modes vs Duration (45 to 59mins)

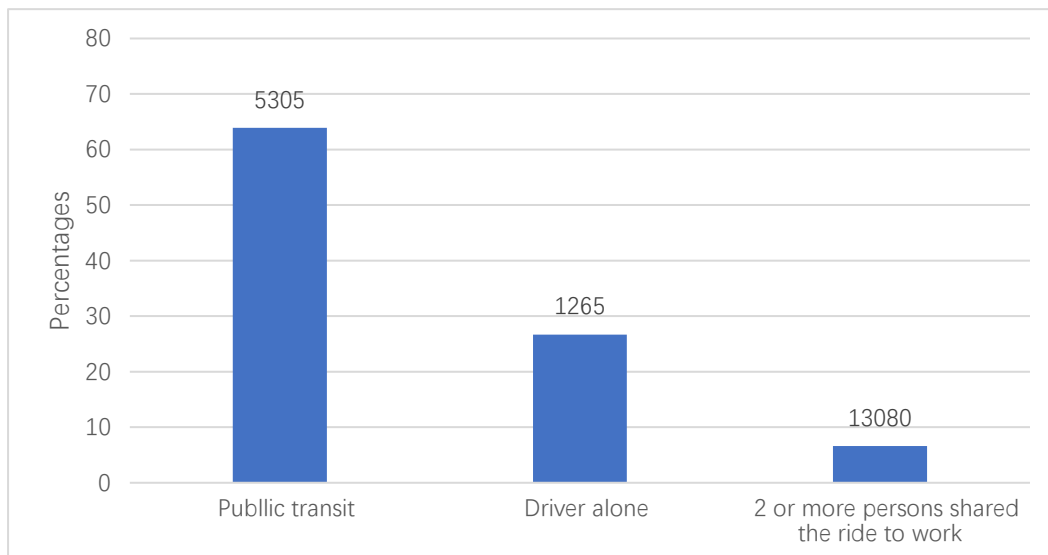


Figure 8: Top 3 Commuting Modes vs Duration (60mins and over)

For workers who commute less than 45 minutes, “Driver alone” is the most common one, followed with “Public transit” or “Walked” (for workers who commute less than 15 minutes). While for workers who commute more than 45 minutes, “Public transit” and “Driver alone” are the most popular commuting mode. Hence, full-time workers who commute by “Public transit” and “Driver alone” are suffering more commuting burdens than other commuting modes.

Common commuting modes might also be different for different income groups in different census tracts, further analysis will also focus on the spatial relationships between commuting modes and income groups for commuting duration more than 45 minutes.

4.0 Static and Interactive Map Analysis

4.1 Employment Centres Distribution:

According to Tabular data analysis, the basic conclusion of the disproportionate commuting burdens can be identified that the full-time workers who commute more than 45 minutes, moderate-income group, and those who commute by “drive alone” or “public transit” are experiencing more commuting burdens in Metro Vancouver. Hence, it is helpful to conduct the employment centres through the heat maps to narrow down the analysis.

Figure 9 is the heat map of the employment centres in Metro Vancouver on census tract level, the numbers of industry locations of census tracts are divided into five categories (i.e., “NA-1,000”, “1,000-2,500”, “2,500-5,000”, “5,000-7,500”, and “7,500-17,220”). As one of the objectives is to conduct the employment centres, census tracts with more than 1,000 job locations are considered as the potential employment centres. In figure 9, census tracts in Downtown, Delta, Richmond, Vancouver airport, and UBC areas are bluer, which means these areas have more job locations than other areas.

Since there are about 45 census tracts providing more than 1,000 job locations, further analysis focuses on the top 10 census tracts and then analyze their characteristics from the aspects of commuting mode, industries, and minorities.

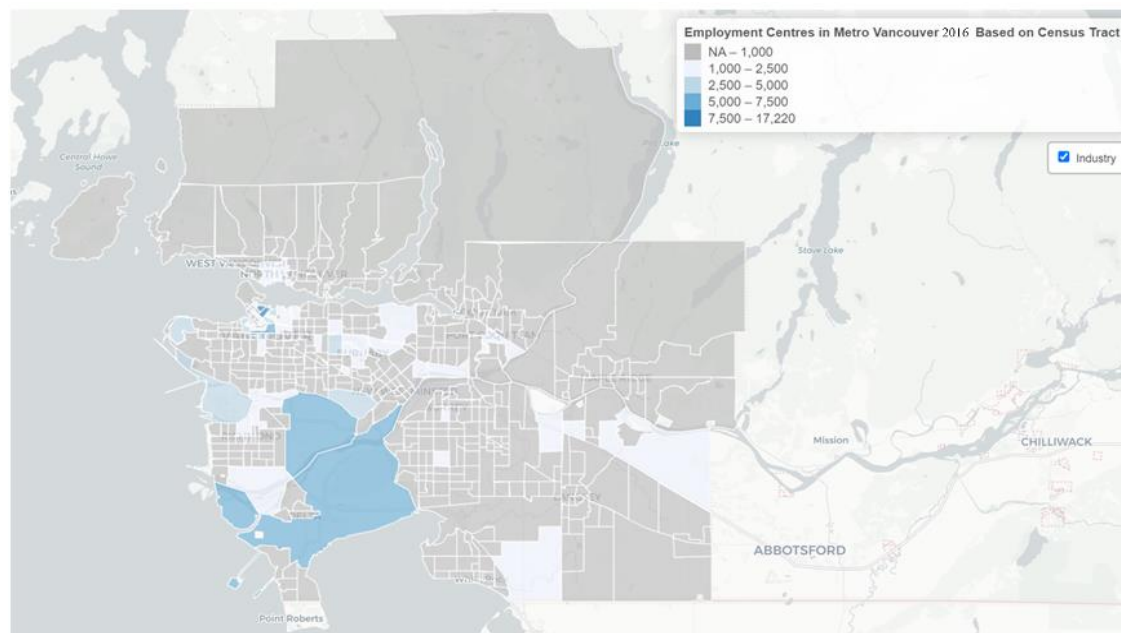


Figure 9: Employment Centres in Metro Vancouver 2016 Based on Census Tracts

Note: Interactive map is in File 1

4.2 Distribution of the Number of Workers with Commutes More than 45 minutes:

Based on the tabular analysis, workers who commute more than 45 minutes to their jobs is further analyzed. Figure 10 is the heat map of the number of workers who commute more than 45 minutes, the more purple census tracts (e.g., Vancouver Downtown, Delta, and Richmond), the more workers who commute more than 45 minutes everyday.

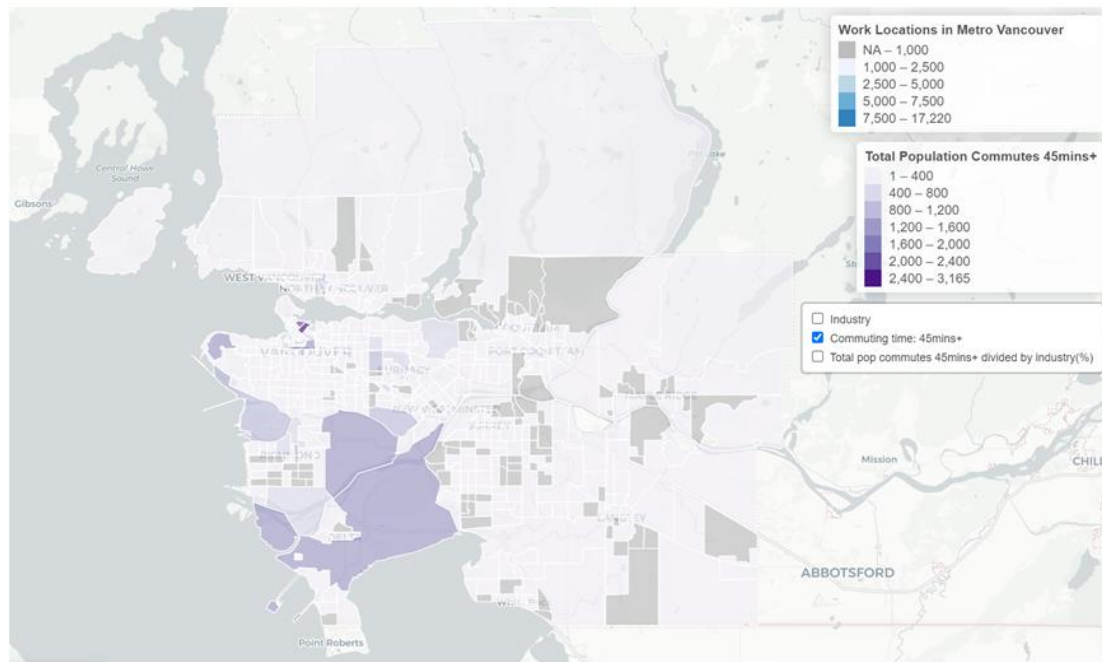


Figure 10: Distribution of the Number of Workers that Commute More than 45 minutes on Census Tract Level

Note: Interactive map is in File 2

To conduct the spatial relationships between industry and commuting duration, “the percentages of the number of workers that commute more than 45 minutes in each census tract” is calculated by:

$$\frac{\text{Total Population Commutes 45mins} +}{\text{Work Locations in Metro Vancouver 2016}}$$

where “Work Locations in Metro Vancouver 2016” only uses the census tracts that have more than 1,000 job locations.

After the above calculation, the top 10 census tracts of “Percent of Duration 45mins+ Divided by Industry” are selected to display in Figure 11, and the grey areas (e.g., the blue circled one) in Figure 11 are the percentages of the total industry that have more than 1,000 jobs but not in the top 10 percentages. Figure 12 lists the census tract IDs for Figure 11.

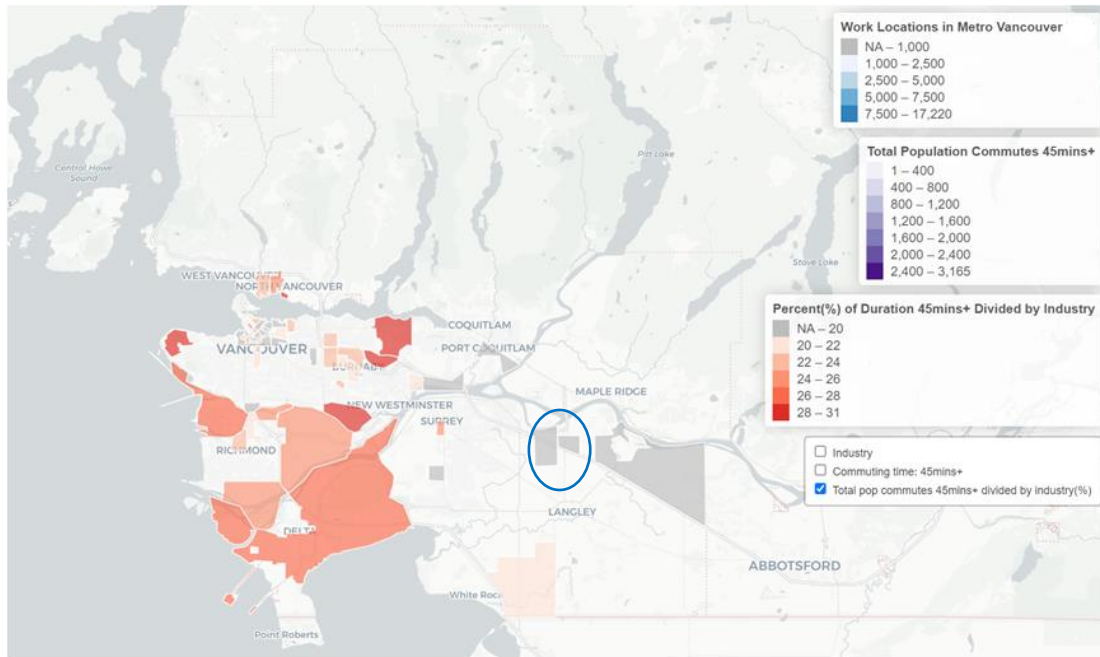


Figure 11: Top 10 Census Tracts of the “Percentages of the Number of Workers that Commute More than 45 minutes Divided by Industry”

Note: Interactive map is in File 3

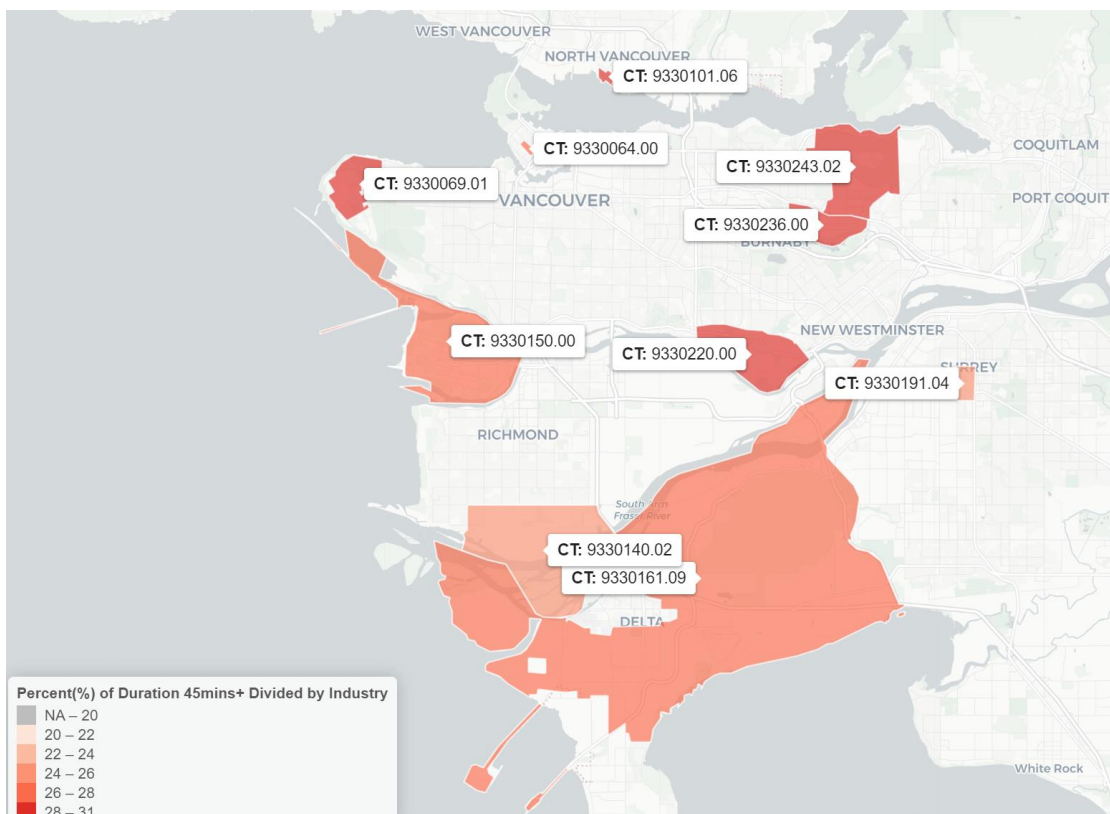


Figure 12: Top 10 Census Tracts of the “Percentages of Commuting Duration More than 45 minutes Divided by Industry”

Note: Interactive map is in File 4

4.3 Analysis of the Commuting Burdens Factors and Heat Maps for Commuting

Time More than 45mins:

To identify worker characteristic correlated with a disproportionate commuting burden, analysis of the workers and the heat map (Figure 12) is conducted according to the employment income, commuting mode, industries, and minorities. In Figure 12, we see that UBC, SFU, and the Delta/Richmond areas are primary locations for long commutes, the listed tables of the commuting burden factors focus on these areas. While other areas tables and analysis can be found in Appendix 2 (for Commuting Mode), and Appendix 3 (Industry for Top 10 Census Tracts). Considering the special location of Vancouver Downtown (highest accessibility to public transit), it is not put in the Appendix.

4.3.1 Commuting Mode:

For each census tract in Figure 12, the top 3 commuting modes are filtered and combined with the income group data to analyze their relationships.

Figure 13 is the zoom in map of Figure 12 and it shows the census tracts 9330069.01 (Vancouver Downtown) and 9330064.00 (UBC). From figure 14, we see that for workers who commute more than 45 minutes in all income groups in these two census tracts, “Public transit” is the most common commuting mode. For moderate- to high-income workers “Driver alone” is their second most common commuting mode, while “2 or more persons shared the ride to work” is the second most common commuting way for low-income workers.

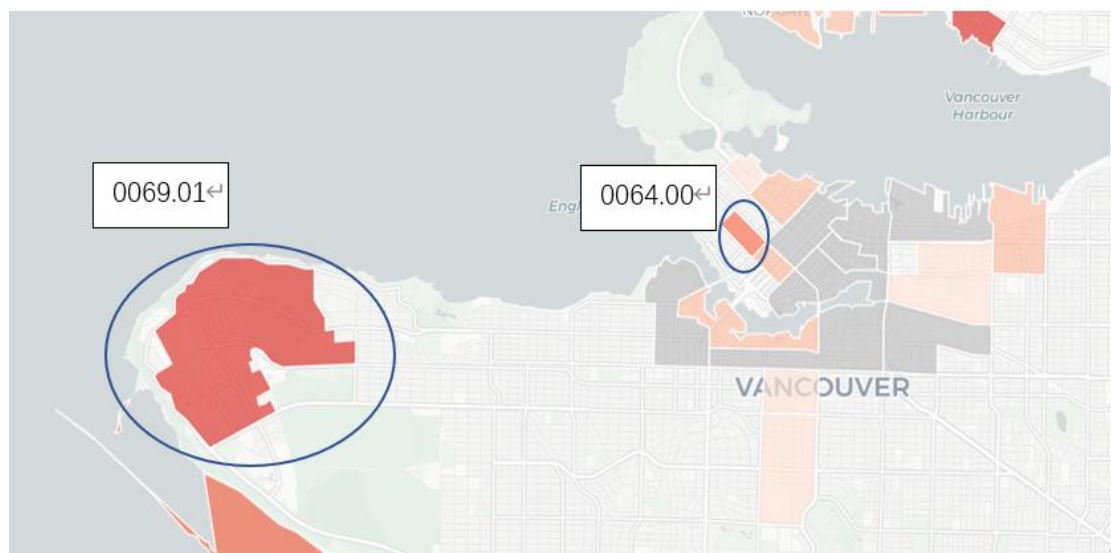


Figure 13: Zoom in Map for Census Tract 0064.00 and 00689.01

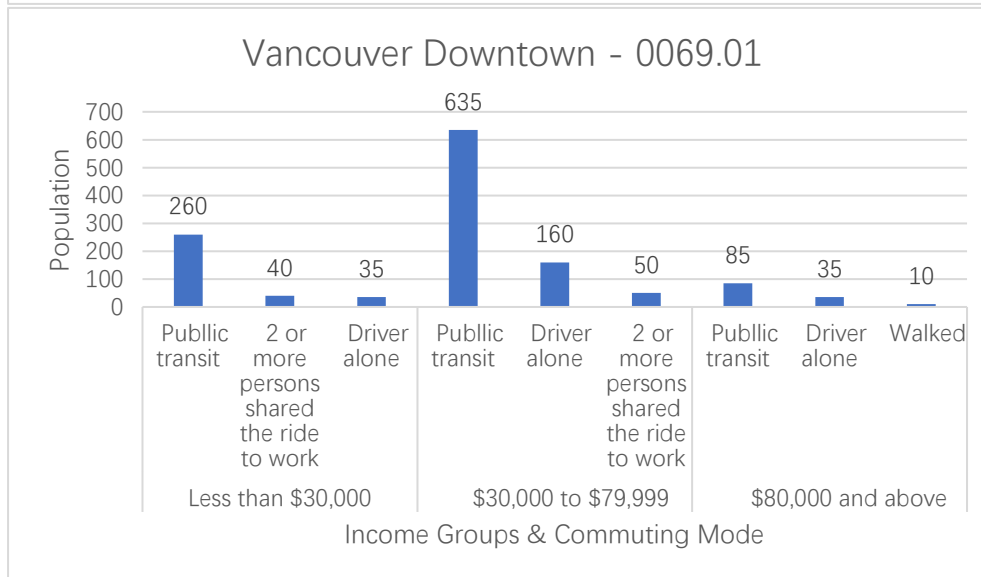
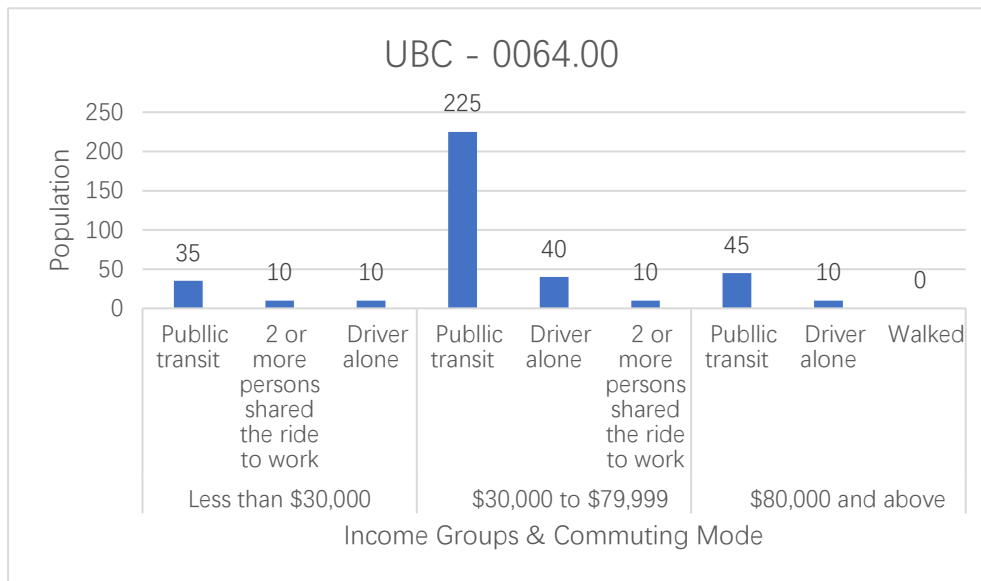


Figure 14: Histograms of Income Groups and Commuting Mode

From figure 15 to 17 are the census tracts that “Driver alone” is the most common commuting mode for moderate- to high-income workers, followed with “Public transit” and “2 or more persons shared the ride to work”. While for low-income workers, “Public transit” is the most common commuting mode. Apparently, “Driver alone” is relatively expensive compared to “Public transit”, which might be the main reason why “Public transit” is the most common commuting mode for low-income workers. While moderate- to high-income workers have a certain financial base, so when they commute more than 45 minutes, “Driver alone” is their best choice as it generally takes less time than “Public transit”.

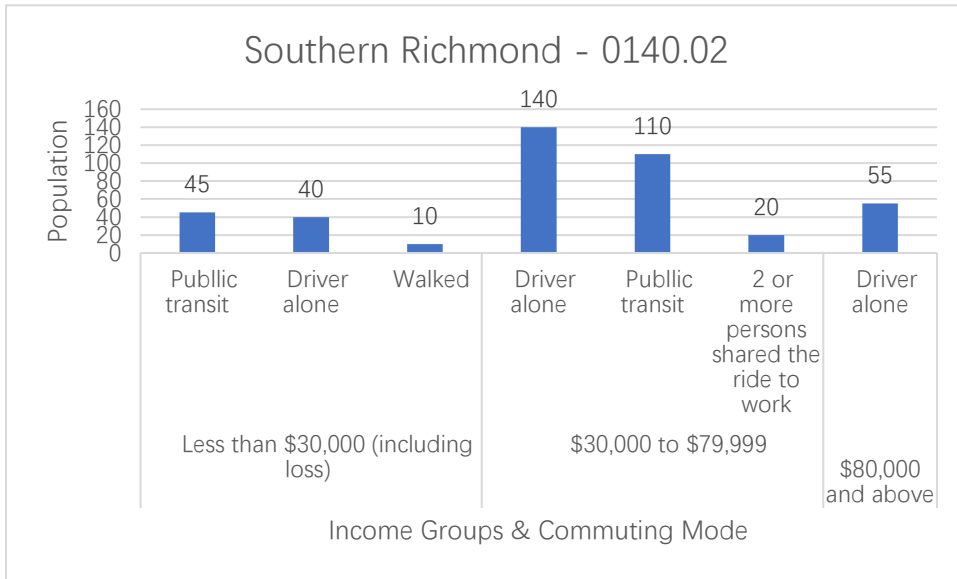


Figure 15: Histogram of Income Groups and Commuting Mode of 0140.02 (Southern Richmond)

Note: the second and third commuting mode for “\$80,000 and above” are 0, so they are not listed in Figure 15.

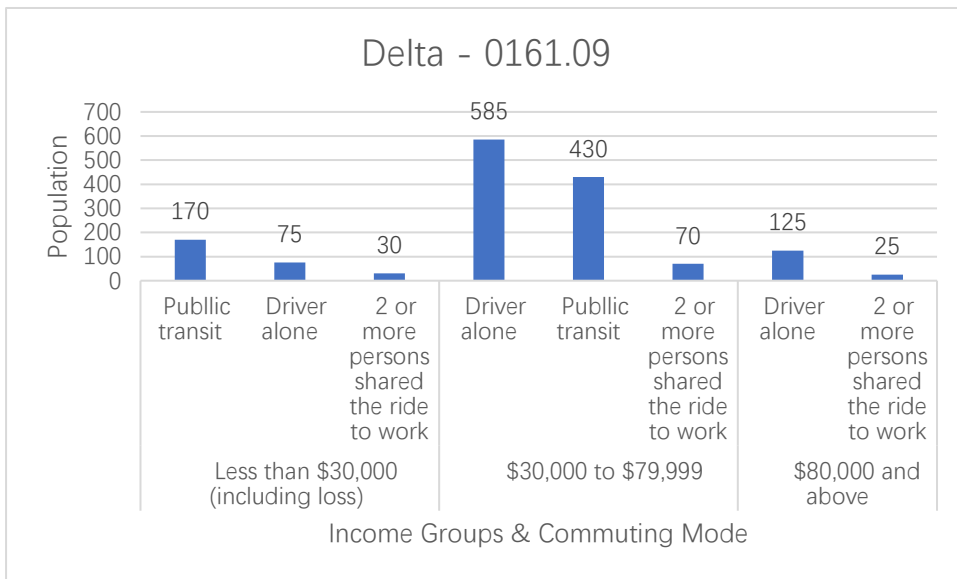


Figure 16: Histogram of Income Groups and Commuting Mode of 0161.09 (Delta)

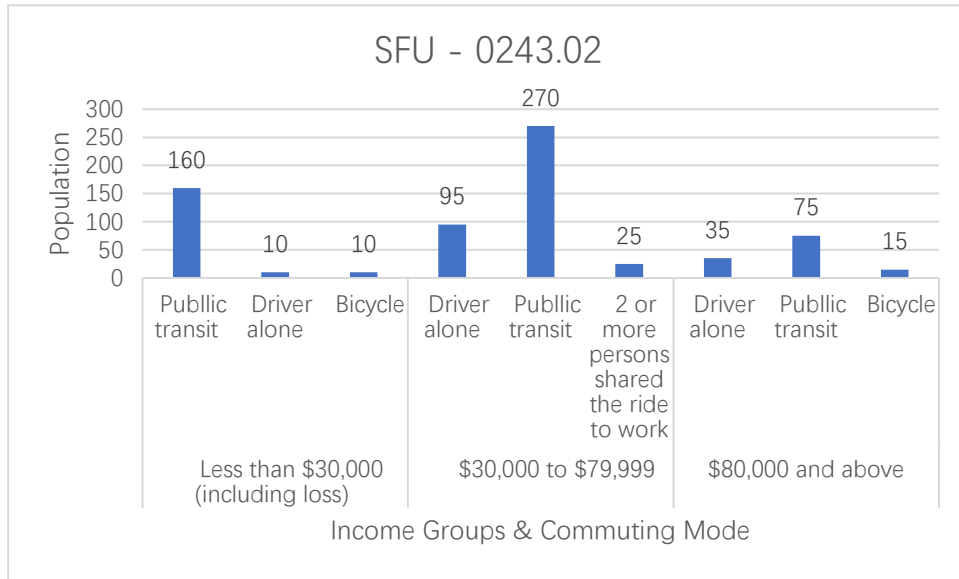


Figure 17: Histogram of Income Groups and Commuting Mode of 0243.02 (SFU)

4.3.2 Industry Analysis for Top 10 Census Tracts:

For each census tracts in Figure 12, the histogram lists the three industries that offer the most jobs.

Refer to Figure 12 and 13, and Figure 18, the three industries that offer the most jobs in the Vancouver downtown census tract are “Hospital”, “Educational services”, and “Food services”. There are St. Pail’s Hospital, VanWest College, and many restaurants and bars, which provides many related jobs.

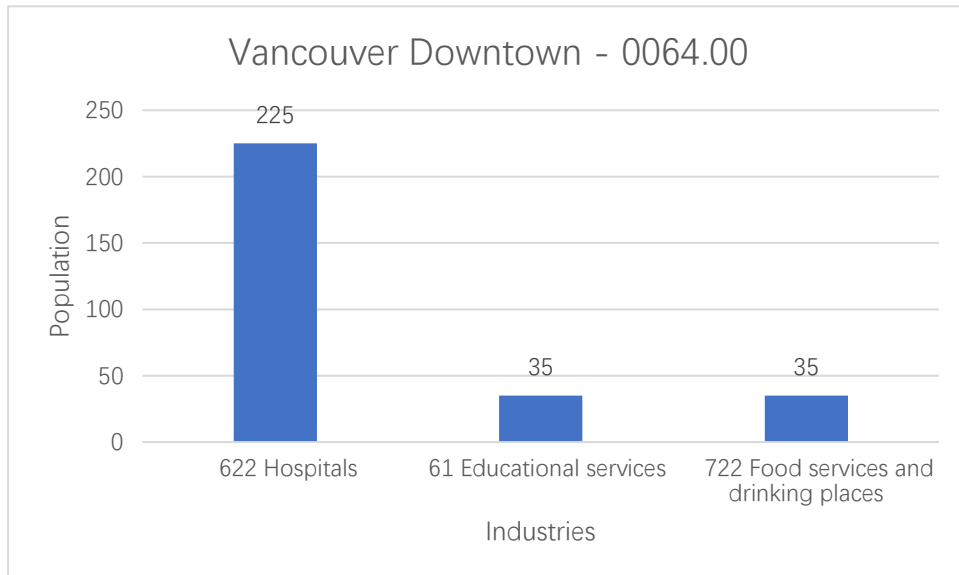


Figure 18: Histogram of The Top 3 Industries of 0064.00 (Vancouver Downtown)

Refer to Figure 12 and 13, and Figure 19, the three industries that offer the most jobs in the UBC census tract are “Educational services”, “Hospital”, and “Professional, scientific and technical services”. There are UBC Hospitals, UBC, and more

importantly, UBC provides many scientific and technical services to their students and workers (e.g., UBC IT), these industries provide many related jobs.

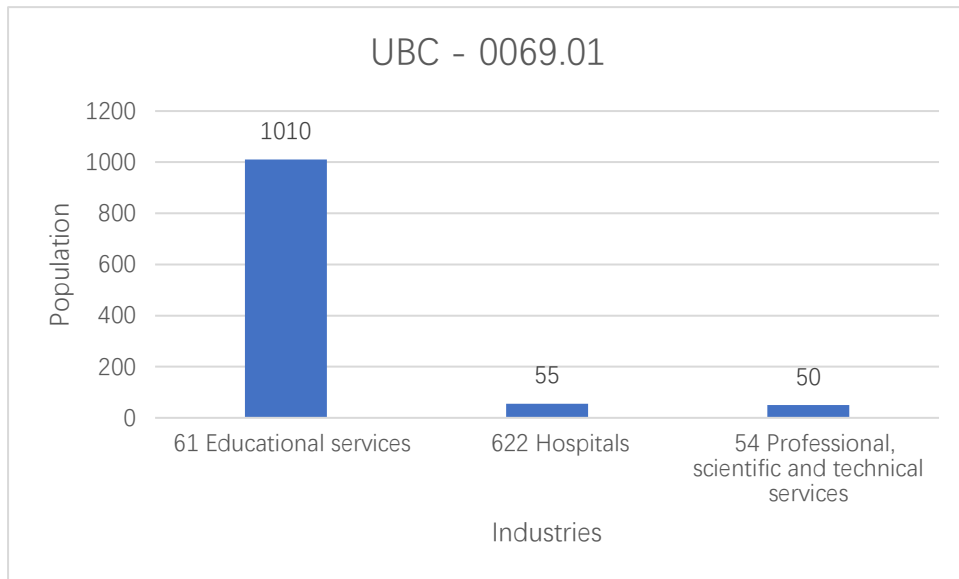


Figure 19: Histogram of The Top 3 Industries of 0069.01 (UBC)

The three industries that offer the most jobs in the southern Richmond census tract are listed in figure 20. There are a series of big manufacturers in Richmond, such as Layfield Group (manufacturing company), and Ark Manufacturing Inc. These manufacturing companies provide jobs related to manufacturing, retail and wholesale trade.

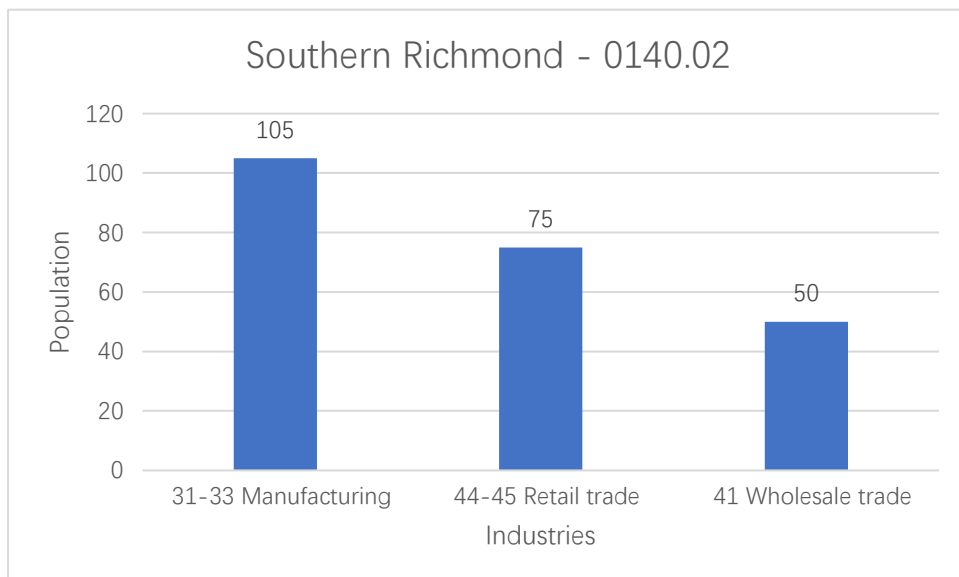


Figure 20: Histogram of The Top 3 Industries of 0140.02 (Southern Richmond)

The three industries that offer the most jobs in the Delta census tract are shown in Figure 22. There are multiple Food manufacturing industries, especially in the blue circled area in Figure 21, such as Earth's Own Food Company Inc., and First Choice

Foods Inc. These manufacturing industries need the wholesale and retail trade industries to help them sell their products, which in turn provides jobs related to the wholesale and retail trade in this census tract.

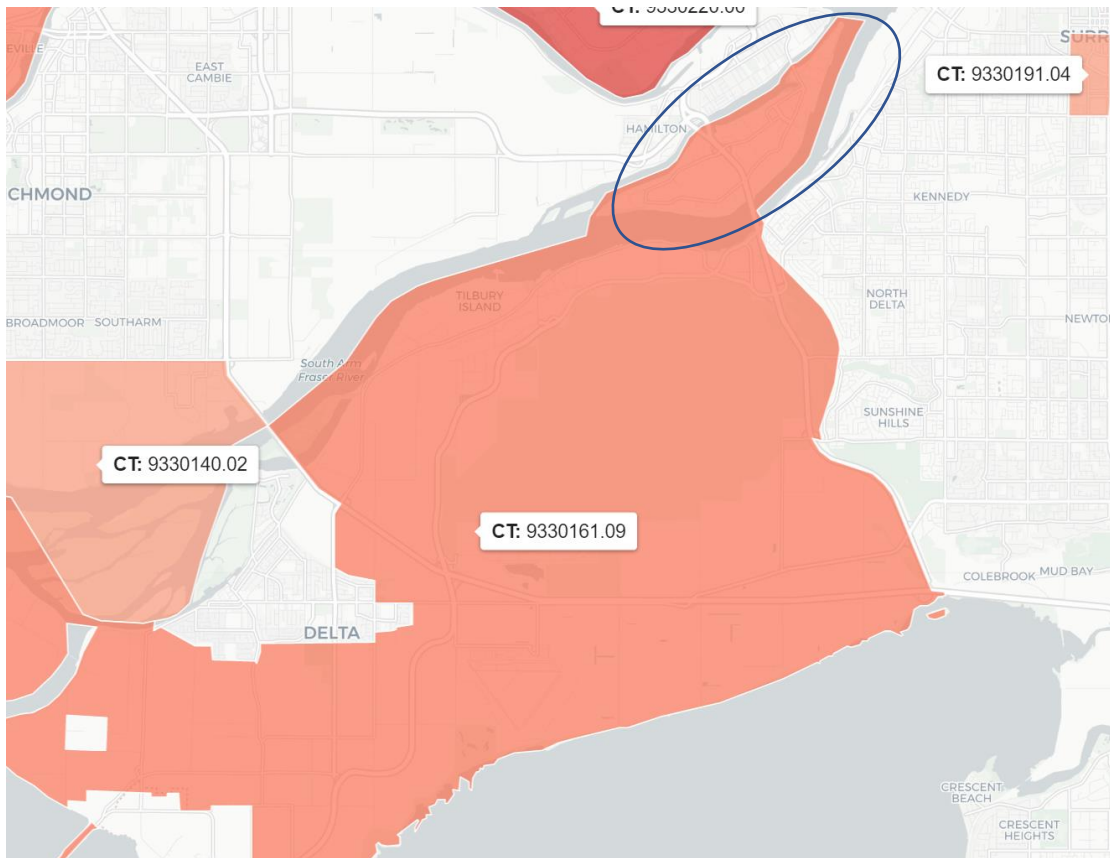


Figure 21: Zoom in Map for 0161.09 (Delta) Census Tract

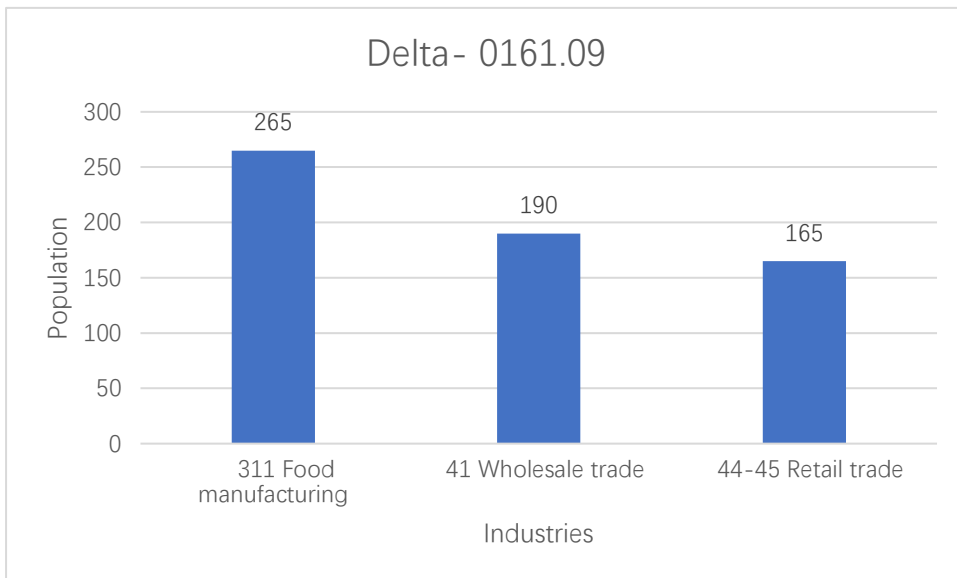


Figure 22: Histogram of The Top 3 Industries of 0161.09 (Delta)

The three industries that offer the most jobs in the Surrey Downtown census tract

are shown in Figure 23. SFU is in this area, it definitely provides jobs related to educational services, and technical services. Forge labs, and Peregrine Retail Design Manufacturing are both manufacturers, hence, they provide manufacturing related jobs.

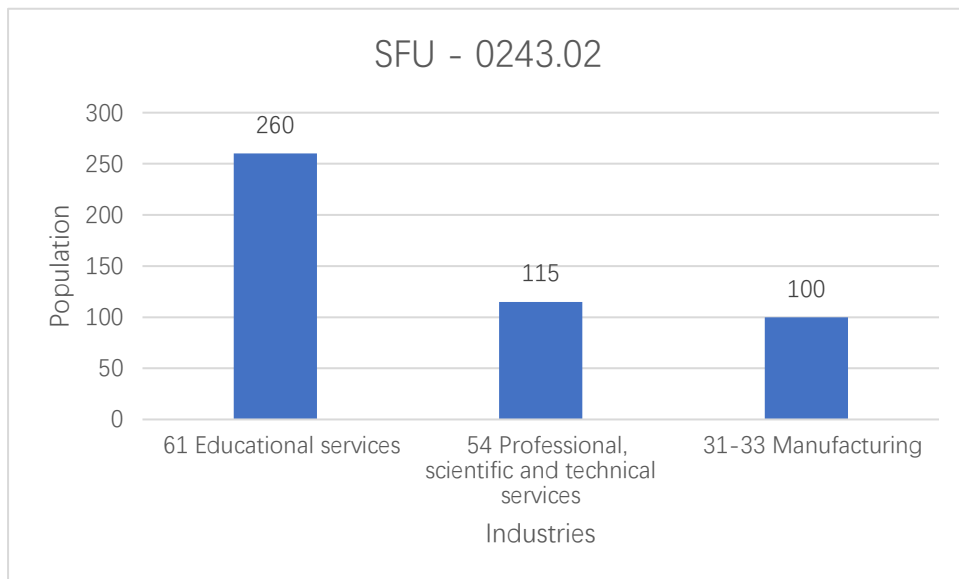


Figure 23: Histogram of The Top 3 Industries of 0243.02 (SFU)

4.3.3 Visible Minority Status:

Analysis for visible minority data is conducted from the regional and the census tract levels, but the researches did not observe any significant effect of visible minority status on workers' duration of commute.

4.4. Distribution of the Number of Workers with Commutes More than 45 minutes within \$30-80,000 Income Group:

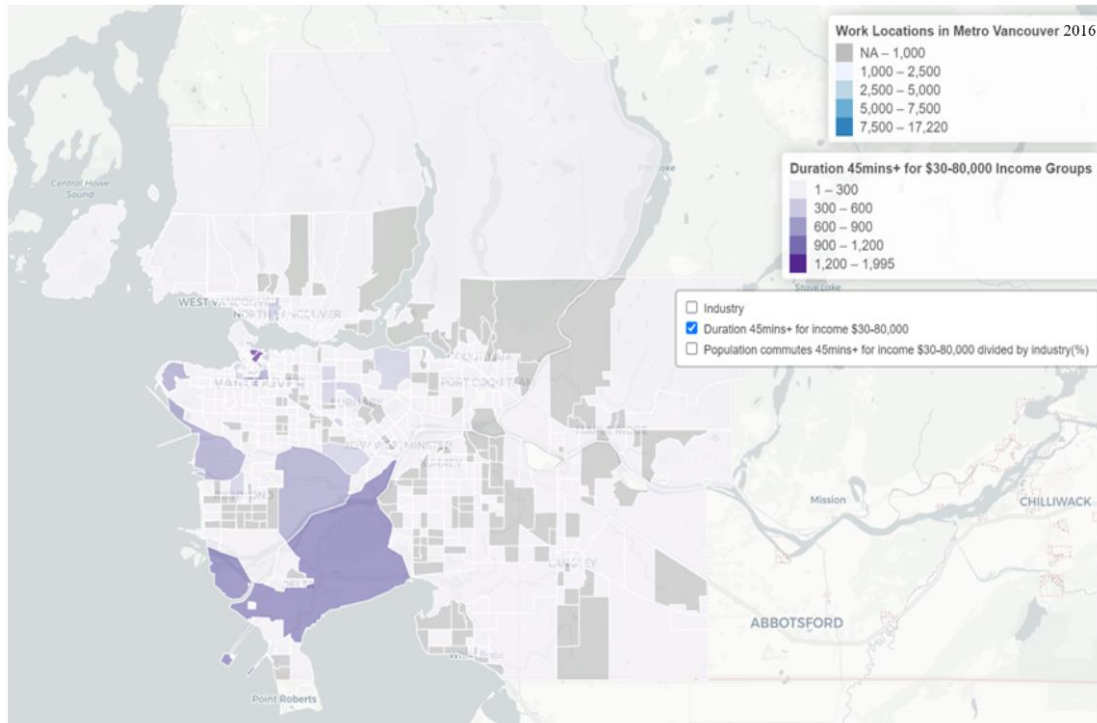


Figure 24: Distribution of the Number of Workers that Commute More than 45 minutes within \$30-80,000 Income Group on Census Tract Level

Note: Interactive map is in File 5

Similar calculation theory to Section 4.2, “the percentages of the number of workers that commute more than 45 minutes in \$30-80,000 income group of each census tract” is calculated by:

$$\frac{\text{Duration 45mins + for } \$30,000 \text{ to } 80,000 \text{ Income Group}}{\text{Work Locations in Metro Vancouver 2016}}$$

where “Work Locations in Metro Vancouver 2016” still only uses the census tracts that have more than 1,000 job locations.

After the calculation, the top 10 census tracts of “Percent of Duration 45mins+ for Income \$30-80,000 Divided by Industry” are chose to display in Figure 25, and the grey areas (e.g., the blue circled one) in Figure 25 are the percentages of the total industry that have more than 1,000 jobs but not in the top 10 percentages. Figure 26 lists the census tract IDs for Figure 25.

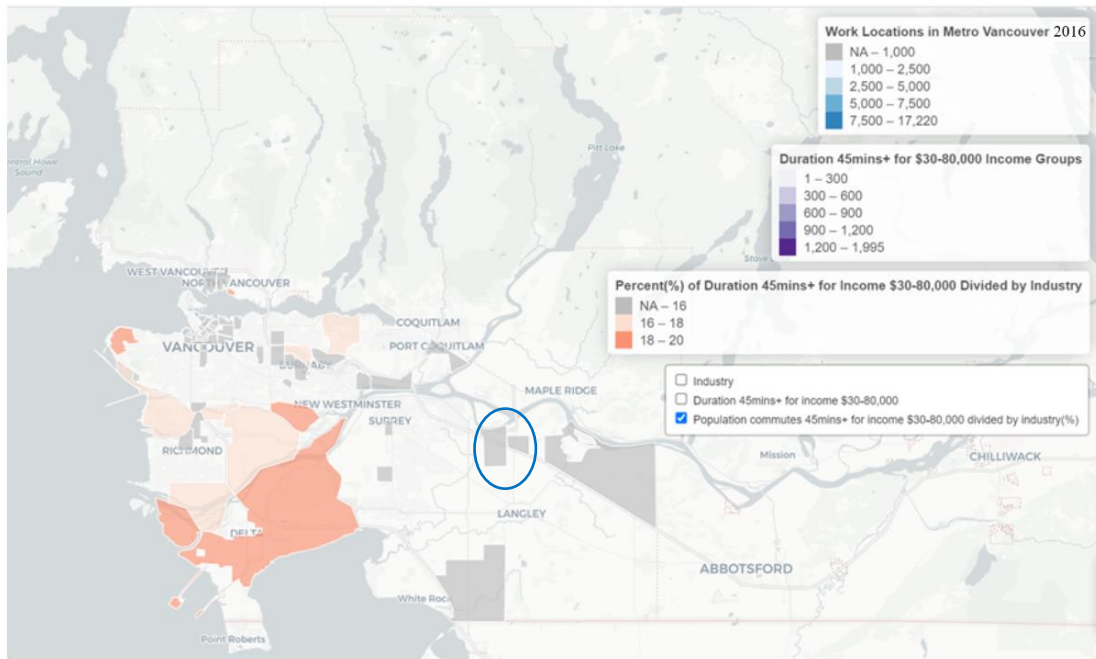


Figure 25: Top 10 Census Tracts of the “Percentages of the Number of Workers that Commute More than 45 minutes within \$30-80,000 Income Group Divided by Industry”

Note: Interactive map is in File 6

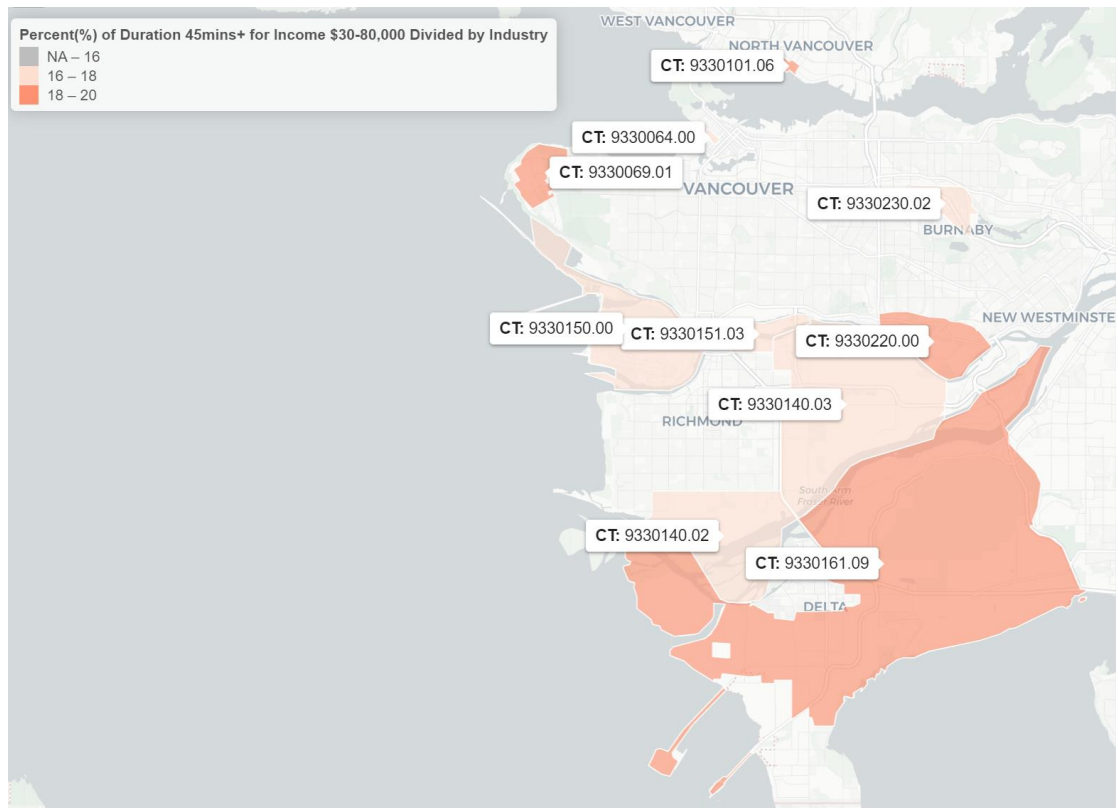


Figure 26: Top 10 Census Tracts of the “Percentages of Commuting Duration More than 45 minutes within \$30-80,000 Income Group Divided by Industry”

Note: Static map is in File 7

Comparing figure 12 and 26, most census tracts are still the same, while CT 0236.00 (Burnaby Downtown), 0191.04 (Surrey Downtown) in figure 12 are replaced by CT 0140.03 (Eastern Richmond) and 0151.03 (Northern Richmond) in figure 26.

4.5 Analysis of the Commuting Burdens Factors and Heat Maps for Commuting Time More than 45 minutes within \$30-80,000 Income Group:

In Figure 25, we see that UBC and Delta areas are primary locations for long commutes in the moderate-income group, hence, the listed tables of the commuting burden factors also focus on these two areas. While other areas tables and analysis can be found in Appendix 2 (for Commuting Mode), and Appendix 4 (Industry for Top 10 Census Tracts). Also, Vancouver Downtown area is not in the Appendix because of its special location in Metro Vancouver.

4.5.1 Commuting Mode:

The analysis of the commuting mode of \$30-80,000 Income Group can be found under Section 4.3.1 (Commuting Mode, includes all income group levels) and Appendix 2.

4.5.2 Industry Analysis for Top 10 Census Tracts for \$30-80,000 Income Group:

For each census tracts in Figure 26, the histogram lists three industries that offer the most jobs.

Refer to Figure 26 and 27, the three industries that offer the most jobs in the Vancouver downtown census tract are “Hospital”, “Nursing and residential care facilities”, and “Food services”. There are St. Pail’s Hospital, Travel Nurse, and many restaurants and restaurants, which provide a large part of the related jobs.

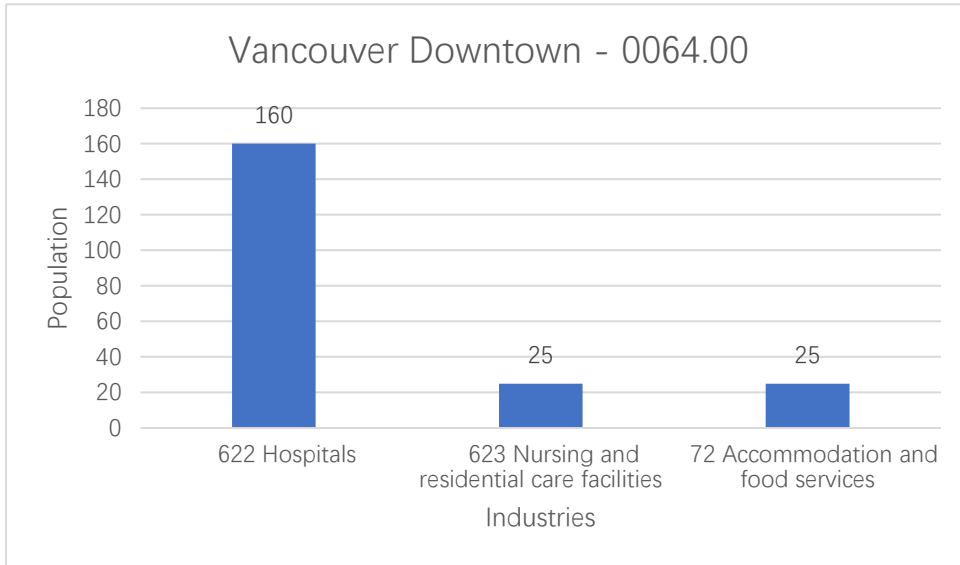


Figure 27: Histogram of The Top 3 Industries of 0064.00 (Vancouver Downtown)

The three industries that offer the most jobs in the UBC census tract are shown in figure 28. There are UBC Hospitals, UBC, and UBC Student Health Services providing the educational services and health care related jobs.

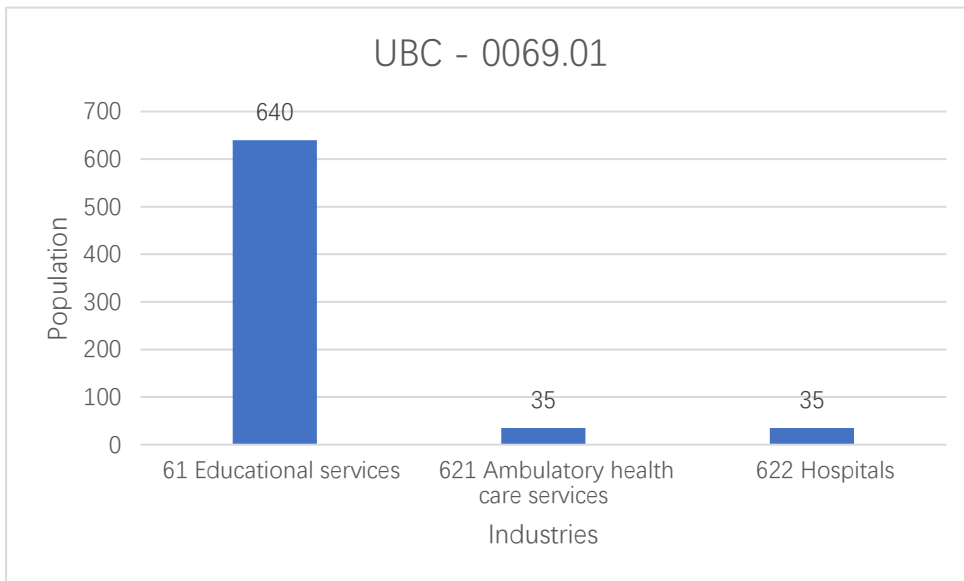


Figure 28: Histogram of The Top 3 Industries of 0069.01 (UBC)

Figure 29 shows the top 3 industries in Delta. There are multiple Food manufacturing industries in this area, such as Earth's Own Food Company Inc., and First Choice Foods Inc. These manufacturing industries need the wholesale and retail trade industries to help them sell their products, which in turn provides jobs related to the wholesale and retail trade in this census tract.

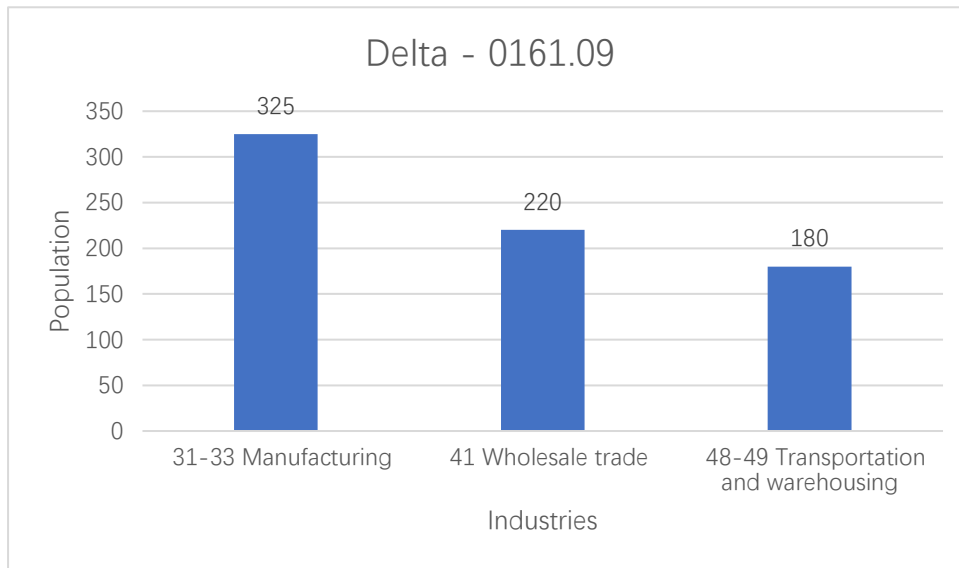


Figure 29: Zoom in Map for 0161.09 (Delta)

5.0 Conclusion

This study focuses on the spatial and descriptive analysis of the relationships between employment location, industry, income, commuting duration and mode in Metro Vancouver. The results of the study indicate that the full-time workers who are experiencing disproportionate commuting burdens in Metro Vancouver are mainly concentrated in the commuting time of 45mins or more, moderate-income groups, and those who commute by public transit or drive alone.

The census tract level maps identify that the primary employment centres for all income groups with commutes of more than 45mins are UBC, SFU, Delta and part of Richmond areas. In these areas, industries that provide more workplaces for full-time workers are concentrated in education, technical services, hospitals, manufacturing, and wholesale and retail trade fields, as there are universities and hospitals in UBC and SFC regions, and many manufacturing plants and retailers are in Delta/Richmond areas. While the commuting mode is very different between different locations and different income groups with long commutes. For low-income groups, public transit has been the most common mode, while for moderate- and high-income groups, both drive alone and public transit are the most common commuting modes.

The census level maps for the moderate-income group show that UBC and Delta are the primary locations for long commutes. Industries that provide more job locations in these two areas are concentrated in educational services, hospitals, manufacturing, and wholesale trade.

As significant relationships between employment income, commuting time and mode, and industry have been identified, this provides support for investments in workforce housing by large employers and non-profit housing providers. Also, employers that have struggled to attract and retain moderate-income workers can use the results of this project to see whether they are looking to attract workers who are

experiencing commuting burdens. The results also provide an opportunity to non-profit housing providers to build partnerships with employers to develop workforce housing with surplus land. By analyzing the commuting activities, we hope this study is helpful to reduce commuting burdens in Metro Vancouver while providing a reference for urban planning and urban livability.

6.0 Limitation

The study has a few potential limitations that could have impacted the results. Moderate-income group has much more full-time workers than other income groups, the more workers in moderate-income group, the more workers are likely to experience commuting burdens. This factor may bias the moderate-income group as the group that experiences disproportionate commuting burdens.

Adding gender data related to industry and commuting time into the original dataset could help the researchers figure out whether gender is a considerable impact on the commuting time, and whether females are in the vulnerable group related to commuting activities and workplace.

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Appendix

Appendix 1:

Number of workers in Metro Vancouver by industry

Industry - North American Industry Classification System (NAICS) 2012	Number of Workers
Total	212825
11 Agriculture, forestry, fishing and hunting	1140
21 Mining, quarrying, and oil and gas extraction	535
22 Utilities	925
23 Construction	8545
236 Construction of buildings	2820
237 Heavy and civil engineering construction	855
238 Specialty trade contractors	4870
31-33 Manufacturing	16615
311 Food manufacturing	3205
41 Wholesale trade	9540
44-45 Retail trade	25815
441 Motor vehicle and parts dealers	3010
442 Furniture and home furnishings stores	1180
443 Electronics and appliance stores	1380
444 Building material and garden equipment and supplies dealers	1370
445 Food and beverage stores	5595
446 Health and personal care stores	2740
447 Gasoline stations	490
448 Clothing and clothing accessories stores	3980
451 Sporting goods, hobby, book and music stores	1415
452 General merchandise stores	1980
453 Miscellaneous store retailers	1655
454 Non-store retailers	1020
48-49 Transportation and warehousing	10745
481 Air transportation	925
482 Rail transportation	290
483 Water transportation	405
484 Truck transportation	1945
485 Transit and ground passenger transportation	1380
486 Pipeline transportation	25
487 Scenic and sightseeing transportation	120
488 Support activities for transportation	2395
491 Postal service	890

492 Couriers and messengers	870
493 Warehousing and storage	1500
51 Information and cultural industries	10445
52 Finance and insurance	9945
53 Real estate and rental and leasing	4965
54 Professional, scientific and technical services	22435
55 Management of companies and enterprises	650
56 Administrative and support, waste management and remediation services	8695
61 Educational services	14925
62 Health care and social assistance	22545
621 Ambulatory health care services	8140
622 Hospitals	6770
623 Nursing and residential care facilities	3290
624 Social assistance	4355
71 Arts, entertainment and recreation	4335
72 Accommodation and food services	20880
721 Accommodation services	3315
722 Food services and drinking places	17560
81 Other services (except public administration)	11245
91 Public administration	7905

Appendix 2:

From figure 30 to 32 are the census tracts that “Driver alone” and “Public transit” are the most common commuting modes for moderate- to high-income workers. While for low-income workers, “Public transit” is the most common commuting mode. Generally, “Driver alone” is relatively expensive compared to “Public transit”, which might be the main reason why “Public transit” is the most common commuting mode for low-income workers. While moderate- to high-income workers have a certain financial base, so more workers choose “Driver alone” with long commutes.

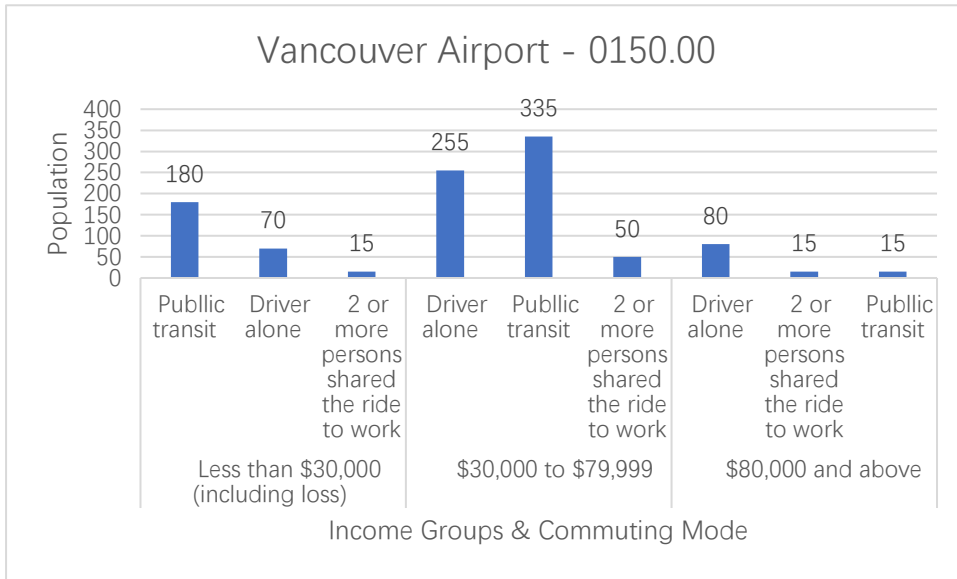


Figure 30: Histogram of Income Groups and Commuting Mode of 0150.00 (Vancouver Airport)

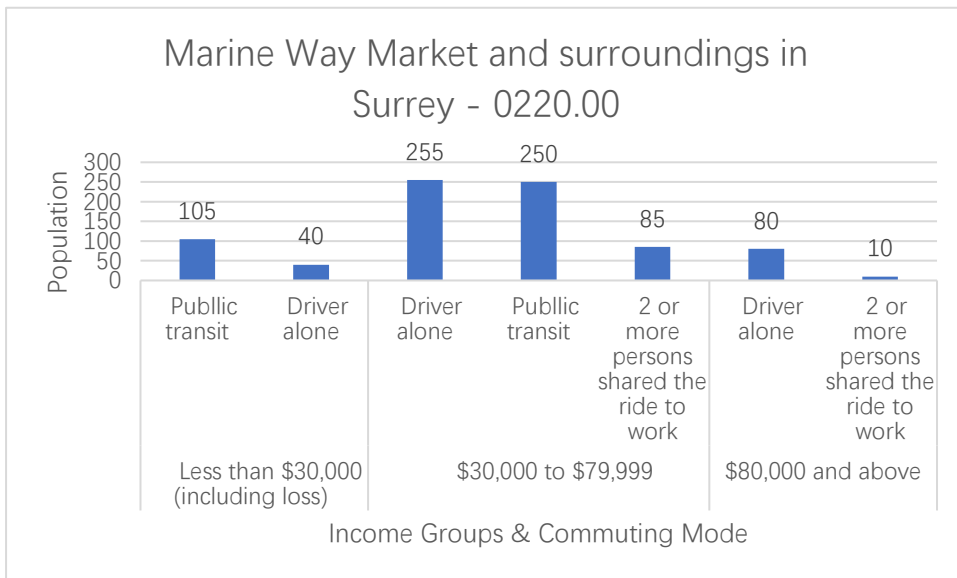


Figure 31: Histogram of Income Groups and Commuting Mode of 0220.00 (Marine Way Market and surroundings in Surrey)

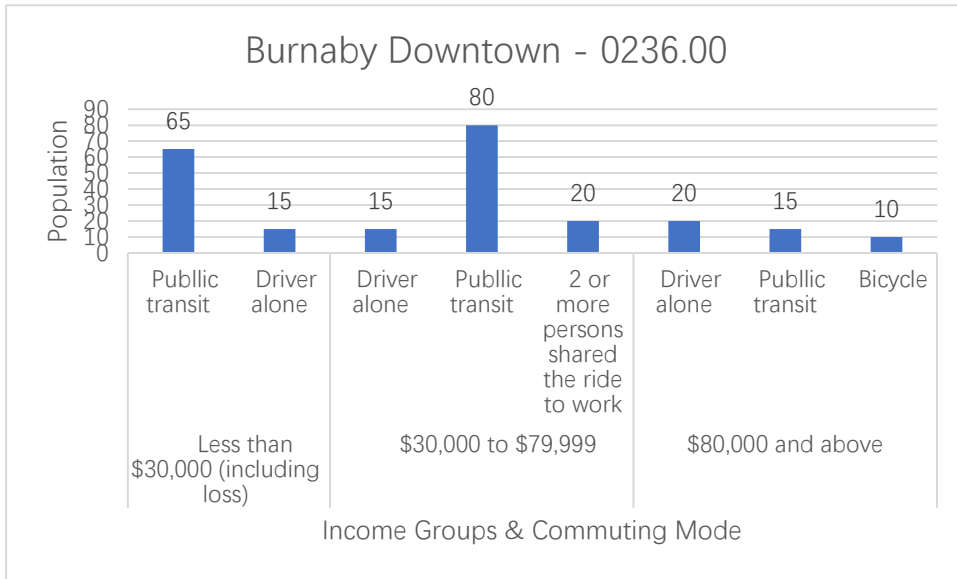


Figure 32: Histogram of Income Groups and Commuting Mode of 0236.00 (Burnaby Downtown)

For census tracts in Figure 33 and 34, the most common commuting mode is “Public transit” for all income groups, and generally followed with “Driver alone”.

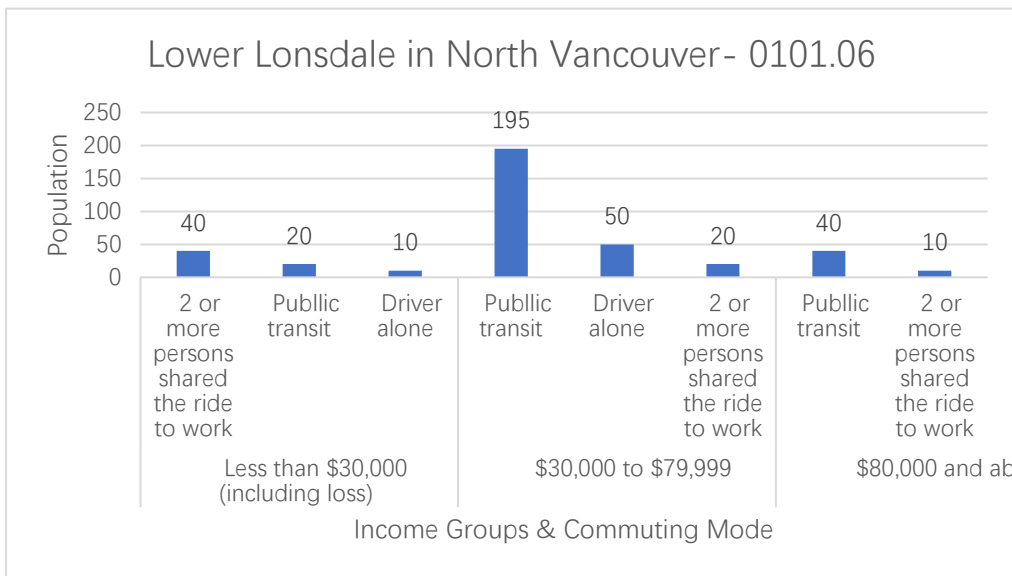


Figure 33: Histogram of Income Groups and Commuting Mode of 0101.06 (Lower Lonsdale in North Vancouver)

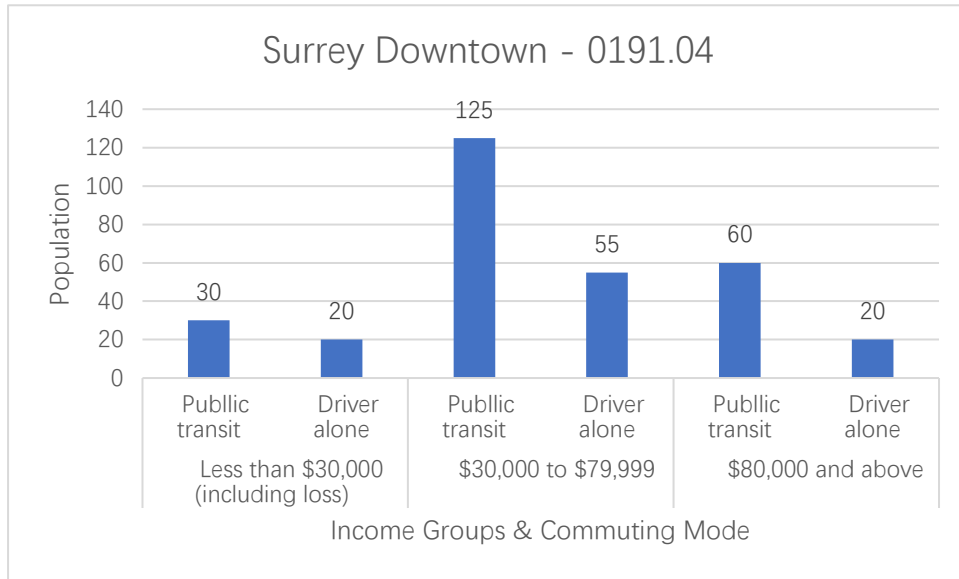


Figure 34: Histogram of Income Groups and Commuting Mode of 0191.04 (Surrey Downtown)

Appendix 3:

Refer to Figure 12 and 13, and Figure 35, the three industries that offer the most jobs in the North Vancouver’s census tract are “Finance and insurance”, “Food services”, and “Construction”. There are multiple financial companies (e.g., Obodo Financial Ltd., and Beddis Financial Svc Corporation), multiple restaurants and bars, and Infinitebuild – North Shore – Custom & Spec Home Builder, these companies provide most of the related jobs.

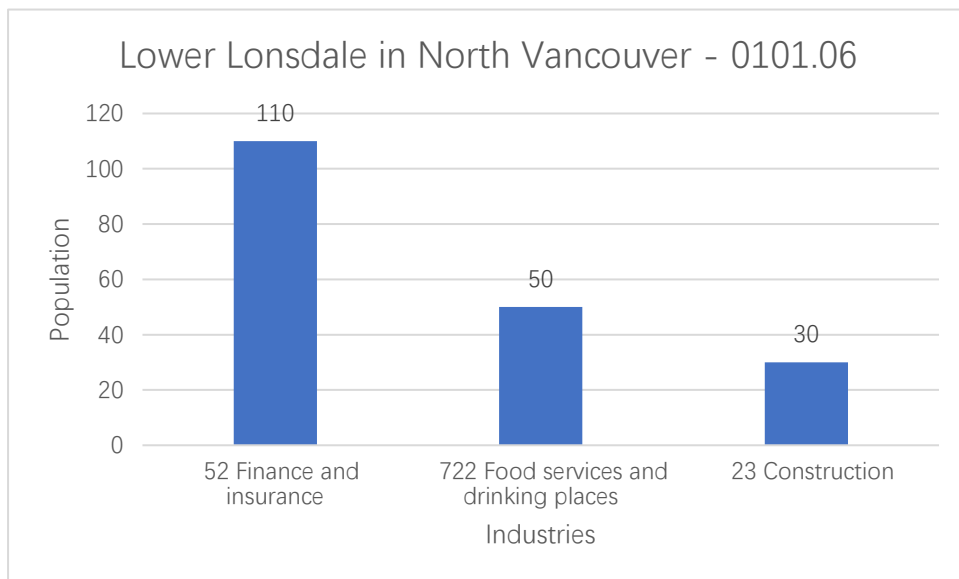


Figure 35: Histogram of The Top 3 Industries of 0101.06 (Lower Lonsdale in North Vancouver)

The three industries that offer the most jobs in the Vancouver airport census tract are shown in Figure 36. As it's an airport area, air transportation, accommodation and food services, and administrative services are critical and necessary for customers and airport staff.

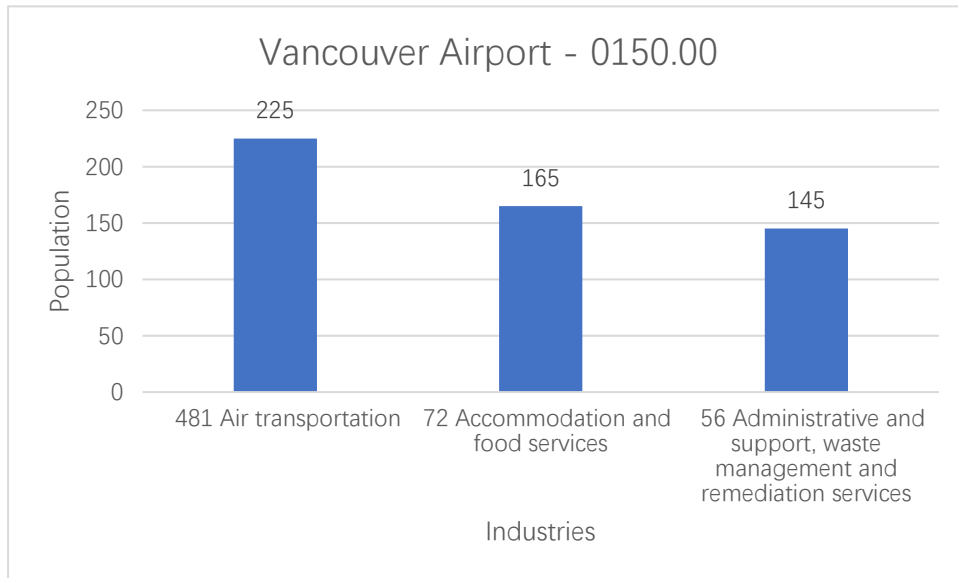


Figure 36: Histogram of The Top 3 Industries of 0150.00 (Vancouver Airport)

The three industries that offer the most jobs in the Surrey Downtown census tract are shown in Figure 37. There are a series of governmental organizations, such as Service Canada Centre, and Surrey City Hall, these agencies belong to “Public administration” and they also provide social assistance to the public. Also, there are Srg Security Resource Group Inc., and LifeLabs Medical Laboratory Services to provide some professional and technical services.

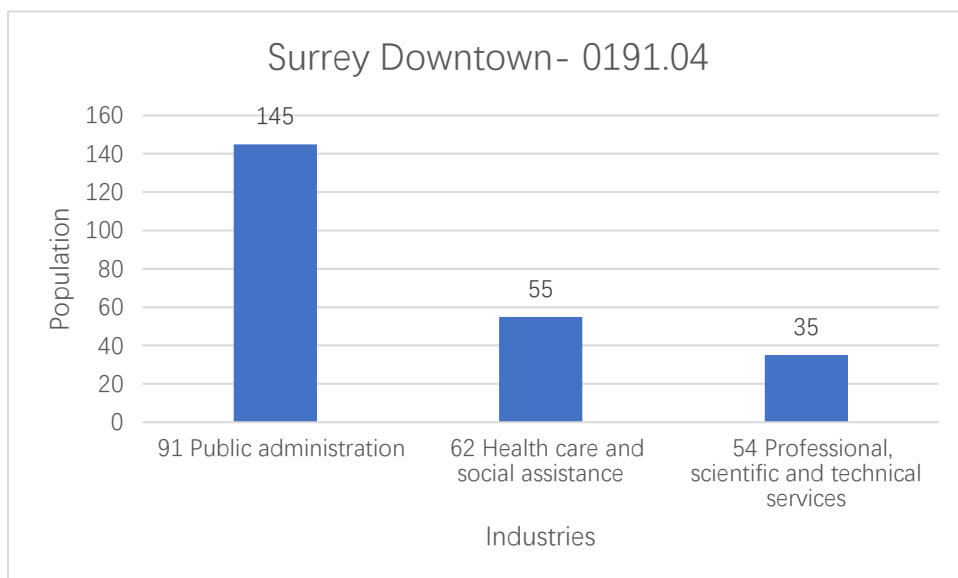


Figure 37: Histogram of The Top 3 Industries of 0191.04 (Surrey Downtown)

The three industries that offer the most jobs in the Surrey Downtown census tract are shown in Figure 38. Creation Technologies (electronics manufacturing), and Columbia Manufacturing Co Ltd. (skylights manufacturing) companies are in this census tract, which provide more jobs related to manufacturing, retail, and wholesale trade. Besides, Source Office Furniture, and Refrigerative Supply (refrigerative supplier) are also in this area, which contribute to the retail and wholesale trade.

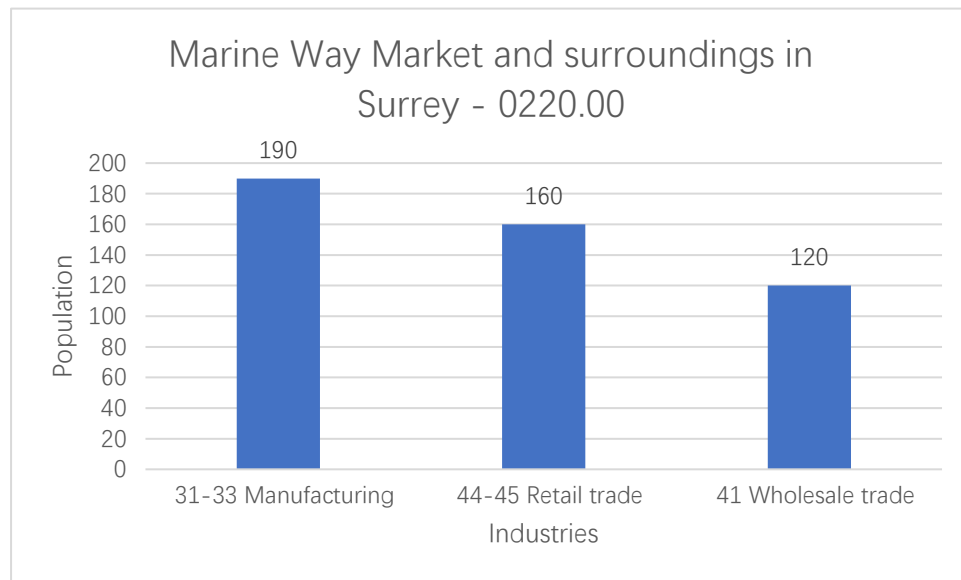


Figure 38: Histogram of The Top 3 Industries of 0220.00 (Marine Way Market and surroundings in Surrey)

The three industries that offer the most jobs in the Surrey Downtown census tract are shown in Figure 39. APT Auto Parts Trading Co. Ltd., and Dryco (Gypsum product supplier) companies are in this census tract, which provide more jobs related to manufacturing, retail, and wholesale trade. Besides, Amazon DVC1 Delivery Station is also in this area, which contribute to the retail and wholesale trade. Related to the professional and technical services industry, Microserve (for IT solution and support), and Pacific Vocational College LTD provide some job chances.

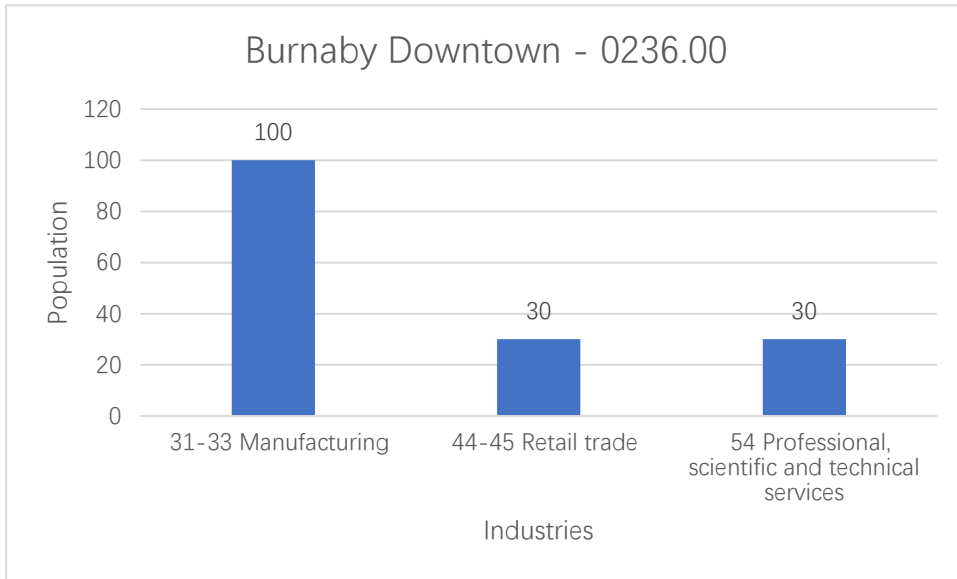


Figure 39: Histogram of The Top 3 Industries of 0236.00 (Burnaby Downtown)

Appendix 4:

The three industries that offer the most jobs in the southern Richmond census tract are listed in figure 40. There are a series of big manufacturers in Richmond, such as Layfield Group (manufacturing company), and Ark Manufacturing Inc. These manufacturing companies provide jobs related to manufacturing, and retail trade. There are also some technical companies, such as TLD Computer and CustomWorks, and Epson Vancouver Design Centre (provide technical service), these companies are related to technical services.

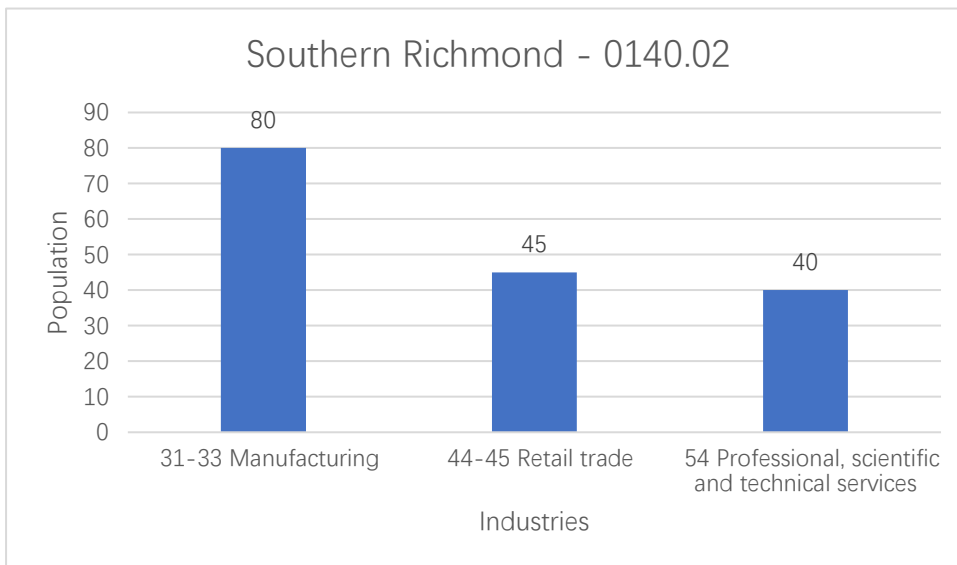


Figure 40: Histogram of The Top 3 Industries of 0140.02 (Southern Richmond)

The three industries that offer the most jobs in the eastern Richmond census tract are in figure 41. There are multiple manufacturing companies in eastern Richmond, such as T D Manufacturing (machine manufacturing), Cascades Containerboard Packaging, and Coe Manufacturing Ltd. (for lumber drying kilns). These manufacturing companies provide jobs related to manufacturing and wholesale trade. This census tract also has many companies such as Vission Technology Inc., and Synapsis Technical Services, which are related to professional and technical services.

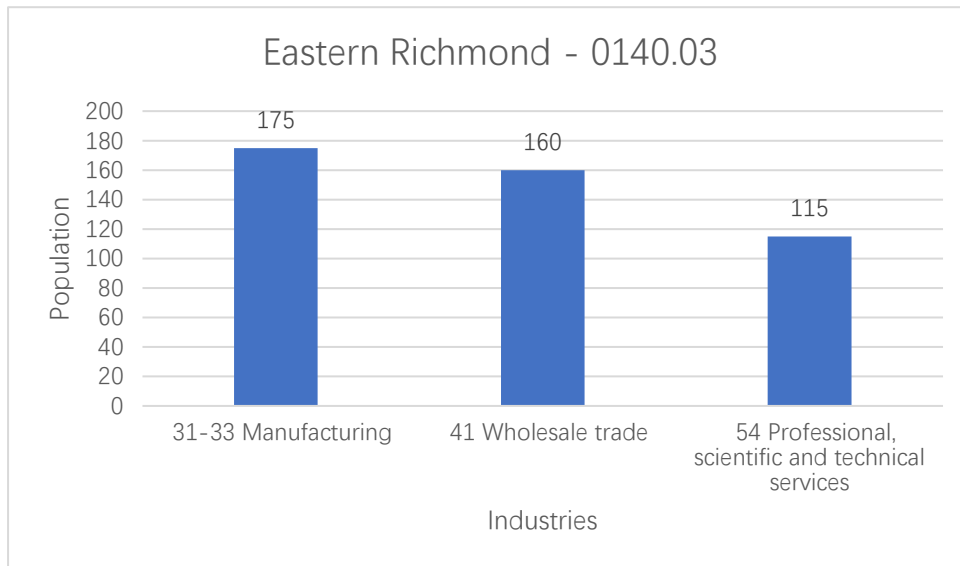


Figure 41: Histogram of The Top 3 Industries of 0140.02 (Eastern Richmond)

The three industries that offer the most jobs in the northern Richmond census tract are in figure 42. There are multiple manufacturing companies in northern Richmond, such as Multi-Form Spring Manufacturing, and EGL Manufacturing Ltd. (plastic resin and synthetic fiber manufacturing industry). These manufacturing companies provide jobs related to manufacturing and wholesale trade. This census tract also has many companies related to transport, such as A Plus Transport Ltd., and VTG Global Transportation Ltd., which are related to transportation and warehousing industry.

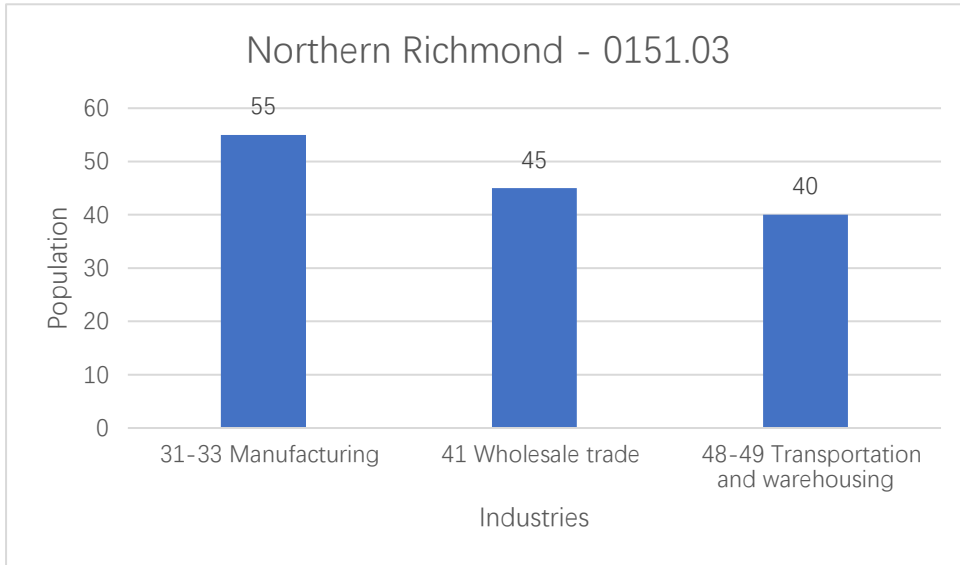


Figure 42: Zoom in Map for 0151.03 (Northern Richmond)

The three industries that offer the most jobs in the North Vancouver's census tract are shown in figure 43. There are multiple financial companies (e.g., Obodo Financial Ltd., and Beddis Financial Svc Corporation), multiple restaurants and hotels, and health care centres (e.g., North Vancouver Community Health, and Vancouver Coastal Health), these companies provide most of the related jobs.

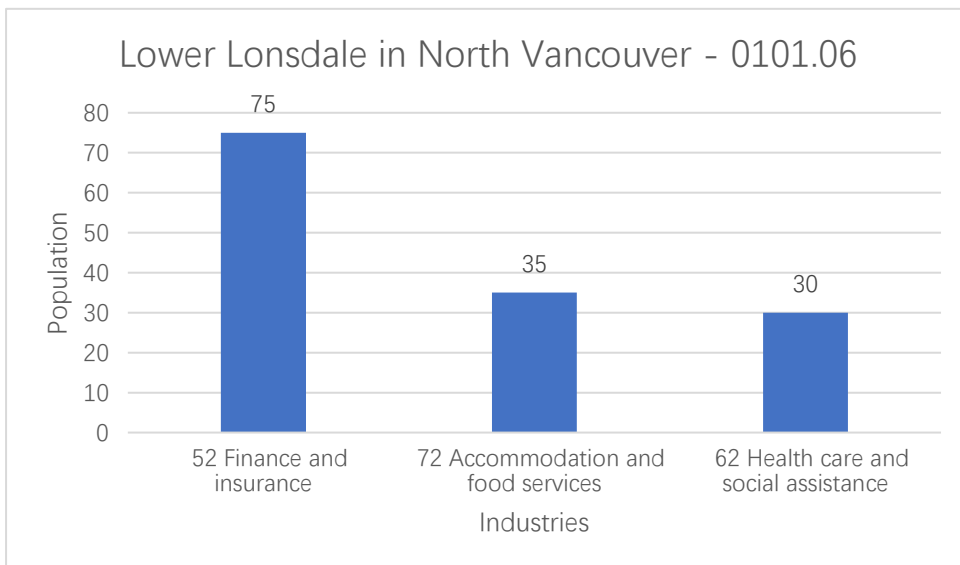


Figure 43: Histogram of The Top 3 Industries of 0101.06 (Lower Lonsdale in North Vancouver)

The industry ranking for this census tract is the same as figure 44, and the analysis of figure 44 can be used here for a further exploration of figure 36.

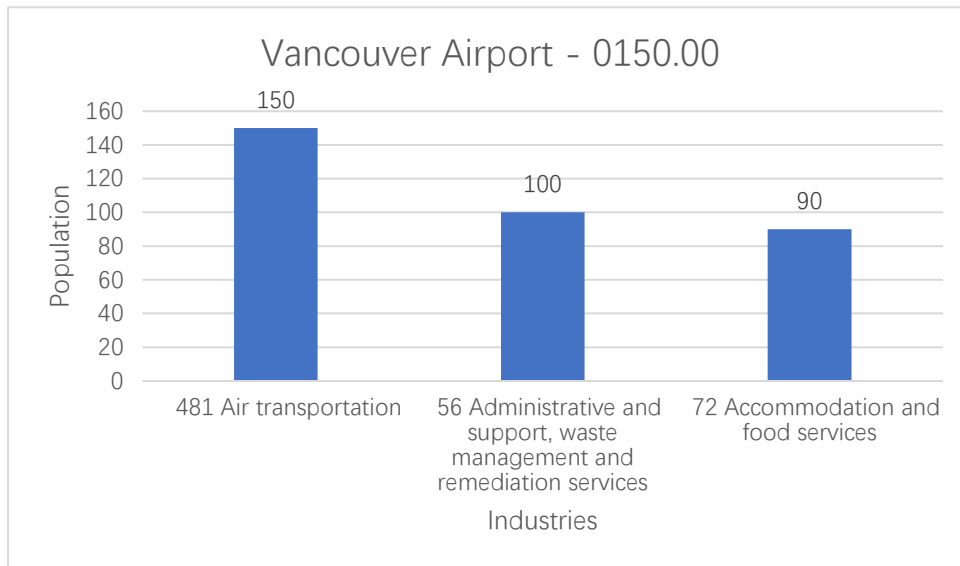


Figure 44: Histogram of The Top 3 Industries of 0150.00 (Vancouver Airport)

The three industries that offer the most jobs in the Surrey Downtown census tract are shown in Figure 45. There are a series of governmental organizations, such as Service Canada Centre, Income Assistance Office, and Surrey City Hall, these agencies belong to “Public administration” and they also provide social assistance to the public. Also, there are Srg Security Resource Group Inc., and LifeLabs Medical Laboratory Services to provide some professional and technical services.

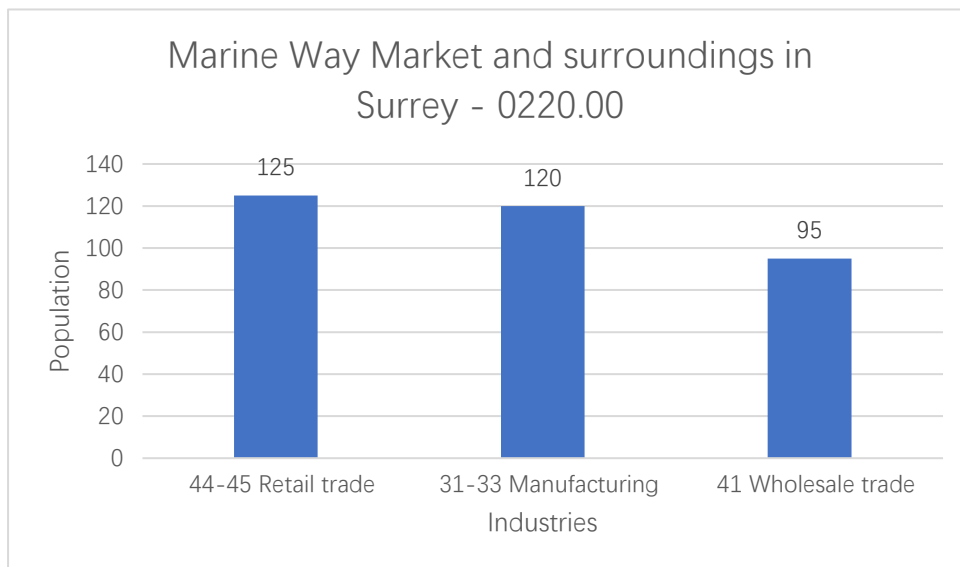


Figure 45: Histogram of The Top 3 Industries of 0220.00 (Marine Way Market and surroundings in Surrey)

The three industries that offer the most jobs in the Burnaby Downtown census tract are shown in Figure 46. Parks Recreation & Cultural Services Administration Office, and Shadbolt Centre For The Arts in this census tract provide more jobs related to Information and cultural industries. There is a Costco Wholesale in this area, which

have more wholesale trade jobs. Moreover, City of Burnaby Still Creek Works Yard (provide waste management services), and Wcs Waste Control Services Inc Fax (waste recycling and management) provide jobs related to waste and remediation services.

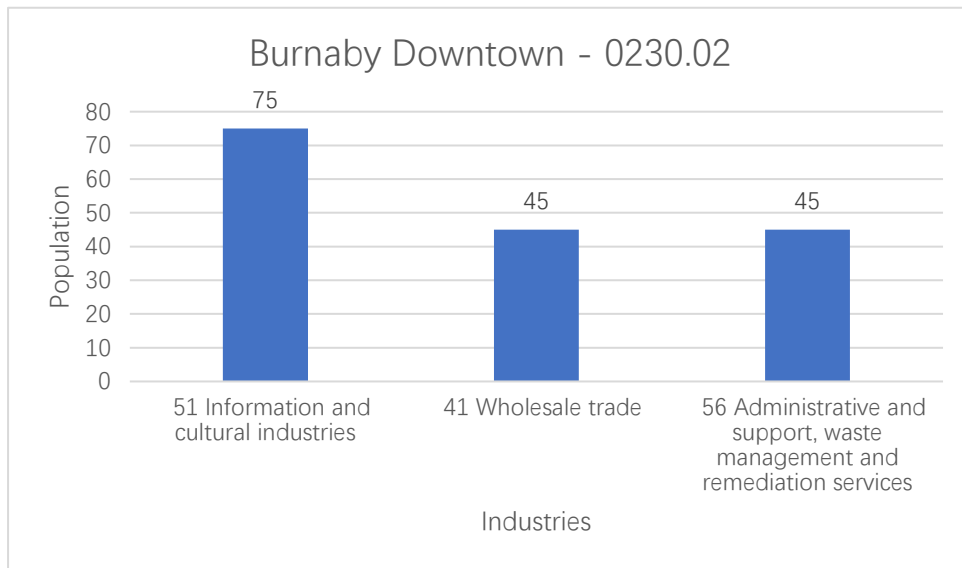


Figure 46: Histogram of The Top 3 Industries of 0230.02 (Burnaby Downtown)