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Master's Thesis

The Travel Behavioral Changes in Sustainable  
Transportation During the Covid-19 Pandemic and Its  
Patterns in Post-Pandemic in Kashiwa City

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## ABSTRACT

In the concept of a sustainable society, one of the primary tasks is to fully accomplish the utilization of sustainable transportation. In specific, the mobility of walking, biking, public transiting, clean energy vehicles, and shared mobility. Increasing the public awareness and the utilization rate of the above-mentioned sustainable transportation in all kinds of situations is an important, yet challenging topic. This paper will look for solutions that will maintain the utilization of sustainable mobility during the pandemic period and provide policy-making suggestions for the post-pandemic recovery.

Under the Covid-19 pandemic, a drastic change in the travel behavior of sustainable transportation could be observed in many regions of the world. The increased number of walking and biking, and the decreasing number of public transiting and shared mobility. The question then comes as follows: what factors triggered these changes? How long will the impact last? Will the citizens continue their current travel behavior even in the post-pandemic? How much do the factors of risk perception, social anxiety, governmental policies, and working and studying style, change their travel behavior? Therefore, studies on travel behavior during pandemics and the prediction of post-pandemic travel behavior are necessary.

To clearly understand the changes in utilization frequency, transport mode, travel purposes, and Covid-19 risk perception, it is necessary to compare the patterns of travel before and during the pandemic. This study also aims to identify the driving forces behind changes in individuals' transportation method changes, assess the perceived Covid-19 infection risk in each sustainable transportation, the information sources, the preferences in choosing a transportation method, the impact of governmental policies and social pressure.

**Keywords:** *Sustainable transportation, covid-19 pandemic, travel behavior changes, risk perception.*

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I would like to thank the University of Tokyo for providing me this excellent opportunity to study about sustainability science and meet amazing professors and young researchers on the campus. These two years of master school indeed fostered my personal growth and enriched my life experience. I will contribute to the society with everything I learned.

This master dissertation is the last work during my academic studies, with all the imperfections and necessary improvements in mind, I will devote into publishing this dissertation one day. Thank you for reading this acknowledgement, best wishes to all of us.

## **TABLE OF CONTENTS**

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

CHAPTER I: INTRODUCTION

Research Background, Research Significance, Problem Statement, Research Objectives

Definition of Sustainable Transportation and Significance of Case Study in Kashiwa City

CHAPTER II: LITERATURE REVIEW

Internal: Covid-19 Risk Perception-Associated Studies

External: Governmental, Media, and Social Influences on Individuals' Travel Behavioral Changes

Studies on the Travel Behavioral Changes Before and After the Covid-19 Pandemic

CHAPTER III: METHODOLOGY

Framework

Secondary Data from Google Community Mobility Reports, and Apple Mobility Trend Reports; MAXQDA Interview Coding; Regression Model of Mail Delivery Questionnaire Using R

CHAPTER IV: RESULTS

CHAPTER V: DISCUSSION

Discussion

Research limitation

CHAPTER VI: CONCLUSION

BIBLIOGRAPHY

APPENDIX

## CHAPTER I: INTRODUCTION

### (1) Research Background

Mobility is one of the greatest challenges that humankind faces today in the field of sustainability. Our World in Data report<sup>1</sup> shows that the annual CO<sub>2</sub> emission produced in 2019 is 36.44 billion tons. WWF<sup>2</sup> suggests that “*around one-quarter of global CO<sub>2</sub> emissions come from the transportation of people and goods.*” In Japan’s case, according to the report of the National Institute for Environmental Studies, the amount of greenhouse gas produced in 2019 was 1,106 million tons. Among them, the transportation sector is responsible for 199 million tons of CO<sub>2</sub> emissions.

These numbers implied the urgent need to reduce CO<sub>2</sub> emissions in the near future, and the necessity to promote eco-friendly transportation methods that are causing a less negative impact on the environment. With this consideration in mind, this paper aims to further develop the topic of sustainable transportation. Sustainable transportation is an eco-friendly transport method that has significantly less or even no cause any forms of violations to the environment. This characteristic explains its importance as a fundamental basis for the realization of a sustainable society. In specific, sustainable transportation includes transport modes of walking, biking, public transiting (bus, train), shared mobility, and clean energy vehicles.

Sustainable transportation is a process that requires long-term development and

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<sup>1</sup> Hannah Ritchie, *Max Roser and Pablo Rosado* (2020)

<sup>2</sup> WWFs One Planet City Challenge 2017-2018.

continuous effort, which means that even under extreme cases, such as large-scale contagious diseases or natural disasters, we still need to prepare countermeasures and devote ourselves to the recovery of sustainable transportation afterward. To fully accomplish the realization of sustainable transportation on a global scale, a continuous effort is required. However, the global pandemic period caused by Covid-19 is leading up to drastic changes in the sustainable transportation travel behavior in the world since one of the most efficient ways to prevent the spread of Covid-19 is reduce frequencies of going outside, and self-quarantine at home. The change of travel frequency, transportation method, destination, and route were significantly influenced by the governmental regulation and individuals' risk perception<sup>3</sup>.

How to overcome the challenges in continuation and promoting sustainable transportation during the pandemic and post-pandemic is the primary concern in this study. To understand and study individuals' travel behaviors during the pandemic and post-pandemic periods, we need to determine the driving factors that caused their behavioral changes. Based on the literature review and data collection, in this paper, the factors will be divided into two aspects, internal reasons, and external reasons. The internal reasons include the Covid-19 infection risk perceived by individuals, their purposes of going outside, their socio-demographic features, and their preferences in choosing a transportation method. The external reasons include government policies, social influences, their ownership of vehicles and bikes.

## **(2) Research Significance**

The study of travel behavioral changes during the Covid-19 pandemic has been proven

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<sup>3</sup> Patrick Singleton, *GRA in civil and environmental engineering*. (2020)

by the scholars in the past studies. For example, Gajendran (2020) believed that the results of the study will help transport planners and policymakers to provide safe transportation services during this period. Thombre (2020) believed that by creating a safer and disaster-resilient public transport, it could contribute to realize sustainable and resilient cities in the context of urban mobility. Huang (2020) believed that the far-reaching significance of understanding the impact of COVID-19 on transportation-related behaviors is to provide more specific policy-making suggestions on anti-epidemic measures.

The utilization of sustainable transportation has changed significantly during the pandemic in different regions of the world. To achieve a sustainable society, we have to consider how to maintain the accessibility and acceptability of each sustainable transportation method under all kinds of situations, including the pandemics like Covid-19. Especially with the fact that Covid-19 will coexist with mankind for a relatively long time, advocating sustainable transportation and strategies to overcome challenges are necessary. In addition, each transportation method has different variables that play as the significant influencing factor roles. It is important to find out the different key factors that influenced the utilization frequency changes of each transportation method and discover the reasons for such differences.

### **(3) Problem Statement**

This paper aim to solve the questions of the changes in utilization frequency of each sustainable transportation method during the covid-19 pandemic in Kashiwa city. To understand their choices and the reasons for them to choose each option. Therefore, to recommend possible future policies of sustainable transportation recovery and

countermeasures during pandemics to Kashiwa city and other similar regions in the world.

During the pandemic, did people's low-risk-perceived travel method match their actual choices? For example, a citizen may assume a private vehicle as the lowest risk, however, he must take public transit because of his occupation, or he simply does not own one. What are the key factors deciding individuals' risk perception? How do individuals perceive the infection risk of each sustainable transportation?

During the post-pandemic, what will be remain? Will people try to walk or bike more to maintain their physical strength? Will individual go back to their pre-pandemic transportation methods? What are the changes people experienced during pandemic and how long will such impact last? How does the remote work and online education situation affect their concept of living?

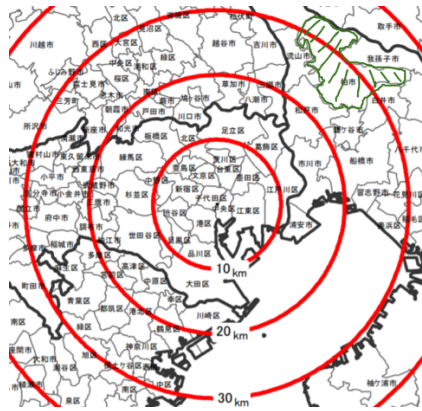
#### **(4) Research Gap and Objectives**

The current studies in travel behavioral changes are mostly focused on a large scale, such as a nationwide, or multi-cities wide range. This study provides a detailed study on a city-region scale in Kashiwa city, which is located in Chiba prefecture. It has an estimated population of 431,873 by July 2022<sup>4</sup>. Kashiwa city is one of the “30 Kilometer cities from Tokyo” as shown in the Graph 1, it is a popular commuting city to people who work and study at Tokyo. In addition, Kashiwa city is also a representative aging city in Japan, it has 26% of the population aged 60 and above by 2020, and expected to have 34.4% of the population aged 60 and above by 2050, as shown in the Graph 2. According to a report from WHO, the world is rapidly ageing. The number of people aged 60 and over as a proportion of the global

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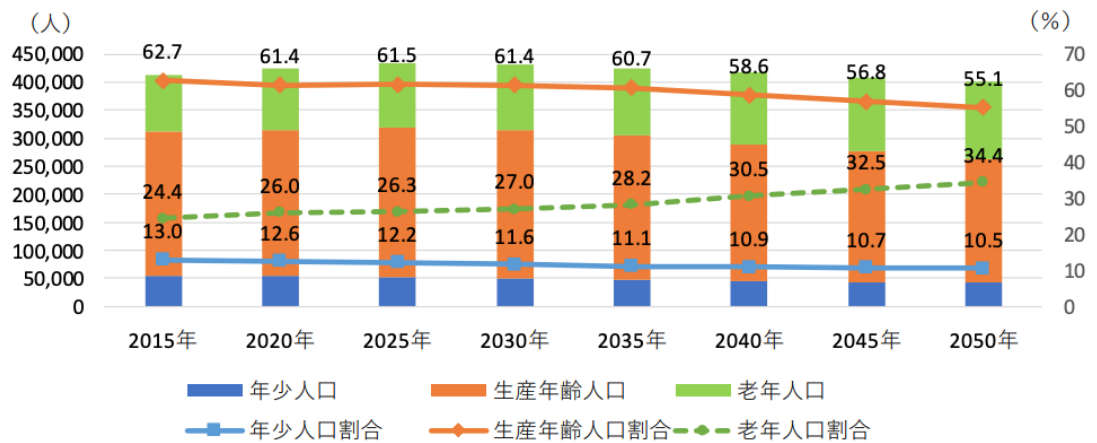
<sup>4</sup> Kashiwa city. 柏市の地理・人口

population will double from 11% in 2006 to 22% by 2050<sup>5</sup>. Understanding the needs and choices of these older people are necessary to understand an aging city, which could then contribute to build an age-friendly city. The research result may easily be replicated in other cities that share similar characteristics. However, the limitations still remain. For places that do not have much in common, the research result in this study may not be possible to generalize.



Graph 1: IPPC report

図表一 61 年齢3区分別人口の推移（ベース推計）



Graph 2: 柏市人口ビジョン（改訂版）2021

<sup>5</sup> WHO. *Global Age-friendly Cities: A Guide*

The other significance of Kashiwa city is that the case study will allow us to have a comparison between the transportation method difference between smart city residents and non-smart city residents. According to Khansari (2020), information generated by the implementation of a smart city has two main impacts. First, it changes residents' social behavior to make better and more sustainable use of city resources (bottom-up approach); Second, it enables service providers (such utilities and transit firms) and local government to deliver better and more sustainable services (top-down approach). This paper will analyze the travel behavior pattern of smart city residents through a bottom-up approach, then enable to provide policy making suggestions for the government and service providers through a top-down approach. In another word, allowing improved government decision-making will enhance the quality of life for city dwellers and the overall sustainability of the city.

This paper will also focus on the individual-level responses on their risk perception level. As Shamshiripour (2020) mentioned, “*very little is known about the individual-level variations in the levels of risk-aversion*”. Since most of the current research were studying about mass transportation tendency, it is necessary to conduct more research on individual level, especially on their attitude studies toward the key influencing factors. In this paper’s case, the detailed attitude towards contradicting governmental policies of “State of Emergency Declaration” and “Go-To Campaign” will be studied.

Last but not the least, most of the studies in the field conducted their questionnaires online only due to the Covid-19 restrictions. However, such method could cause biased situation and excluded population with no access to internet. Therefore, this paper will distribute questionnaires through direct mail delivery base on the percentage of population in

the region, which will avoid biased situations, and include people who cannot access the internet as well.

Overall, this paper is planning to fill the following research gap: (1) Lack of empirical data on the utilization rate of each sustainable transportation method before and during the pandemic; (2) The perceived infection risk did not cover each sustainable transportation method; (3) In term of governmental policy influence, only focused on the impact of restriction policies, such as lockdown, and excluded the policies that stimulate individuals' incentives to go outside.

To address the above-mentioned research gaps, I would like to introduce the research objectives in this paper. The general objective is to assess the changes in the utilization of sustainable transportation for Kashiwa city's residents. Compare the travel behavior before and during the pandemic. Compare the travel behavior before and during the pandemic. Estimate the influence of each variable on travel behavior changes. The specific objectives are to (1) To explore citizens' risk perception towards each sustainable transportation mode during the pandemic. (2) To compare the public acceptance and utilizing frequency of each transport mode in normal and pandemic periods. (3) To compare the differences between city-region situation and prefecture/nation-scale. (4) To propose transport-related recommendations for future policymaking. To meet these targets, the methodology I will be using are secondary data analysis, interviews, and questionnaires.

## CHAPTER II: LITERATURE REVIEW AND RESEARCH GAP

### **(1) Studies on the travel behavior changes before and during the Covid-19 pandemic**

In most countries in the world, individual travel behavior patterns have been significantly influenced by the Covid-19 pandemic and show different patterns compared with the situation before the pandemic. Generally speaking, the biking and walking utilization rate increased, while the public transportation decreased. In the former's case, a case study conducted in Toronto, the government initiated a policy called "ActiveTO" which aims to close some vehicles' roads to create a more walking and biking-friendly environment (Loa 2021). In contrast, public transportation appeared to decrease drastically during the pandemic, according to Molloy (2021), there is "*reductions of around 60% in the average daily distance were observed, with decreases of over 90% for public transport*" in Switzerland.

In many countries in the world, travel behavior has experienced drastic changes. In Turkey, as Shakibaei (2020) mentioned, Istanbul citizens experienced different stages of travel behavioral changes. Before the pandemic, most car-owners used public transportation due to the high costs of fuel. However, during the pandemic, all of the car owners chose to drive instead of public transiting. Such a phenomenon revealed the fact that Istanbul citizens prioritize health over money during the Covid-19 pandemic. However, Istanbul has a different trend of sustainable transportation utilization during the pandemic, which is the decreased use of biking. The reason is geographical restrains since the city's numerous downhill and uphill roads are not friendly to bicycle users.

In India, Gajendran (2020) claimed that during the Covid-19 lockdown, the people are

more dependent upon the personal mode of transportation and the use of shared mobility dropped by 35% compared to the normal situation. Walking and biking increased 22% during the pandemic. Also, the higher-income group and the lower-income group have different travel behavioral changes in the utilization of public transiting. The former will avoid mass transport, yet the latter must rely on mass transport even during the pandemic, due to their differences in financial ability.

In Dutch's case, according to de Haas(2020), under the impact of 'intelligent lockdown' policy, there was roughly 80% of the total population who reduced their activities outdoors. Also, the number of trips made and the distance traveled both decreased by 55 and 68 percent, respectively. Tours by bicycle or on foot had become more popular than they use to. On the other hand, public transportation such as bus and train, is currently perceived much more negatively than the private vehicle. This paper also conclude that the travel behavioral changes occurred during the pandemic, biking frequency increase in specific, has 20% respondents agreed that they will continue biking more frequently during post pandemic as well.

## **(2) Internal: Covid-19 infection risk perception, travel purposes, sociodemographic features, preferences in choosing a transportation method**

To justify and understand the travel behavioral changes caused by the internal variables of the Covid-19 infection risk perceived by individuals, their purposes of going outside, their socio-demographic features, and their preferences in choosing a transportation method, this chapter will summarize the findings from the literature review to support author's choices in these internal variables.

When talking about risk perception, there are many available methods to measure how individuals perceive the risk level of certain tested objects. In the case of the Covid-19 pandemic, Parady (2020) conducted a panel web-survey facing to respondents from Kanto area, he measured the risk perception, in particular, the dread, unknown, and controllability level, through comparison with other diseases and diesters threats. Such as influenza, tsunami, earthquake, etc. This methodology provides a clear image of how people compare the new threat with old threats. Therefore, helped the field to understand the specific risk perception of individuals. However, one of the limitations in Parady's studies, is that in many situations, the risk perception varies differently and does not necessarily match the actual risk. In addition to the perception of risks, Parady also believed that social influence played a main role in affecting non-work-related travel behavioral changes. After evaluating how much do other people's expectations influence individuals' non-work-related travel behaviors, Parady concluded that "*Social influence is associated with increases in going-out self-restriction probability for eating-out and leisure*".

As Chan (2020) mentioned that risk attitudes, rather than actual risk, influence the real behavioral activity of people. Since the risk of being infected by Covid-19 differs in terms of age, education, physical strength, commuting requirements, living locations, etc. The possibility of individuals being infected cannot be measured on the same scale. Therefore, instead of measuring the actual risk for individuals to be infected, the individuals' risk attitudes will be easier to be observed. Their risk attitudes are the driving factors for their behavioral changes during the pandemic.

In addition, there are side effects of risk-perception of individuals. For example, the

mental health. Abu-Rayash (2020) mentioned in his research, that “*the majority of the world is in a state of mental distress and will experience nervousness and anxiety issues post-COVID 19. This sentiment is strongest in India (78%), Japan (77%), China (72%), the U.K. and Mexico (71%), and Brazil and Canada (68%)*”. From this result, we could know that a great number of Japanese people are highly possible to experience traumas post-pandemic. This indicates that the lifestyles will not immediately go back to the normal situation even after the pandemic. The travel behavior might stay the same pattern either. Therefore, the studies on travel behavior during post-pandemic will be crucial as well.

According to the data Huang (2020) analyzed from Baidu, “The most dramatic change in people’s travel patterns is that the start and endpoints of navigation are replaced by residential areas from transport facilities”

### **(3) External: Governmental, media, social influences, ownership of vehicles and bikes**

To justify and understand the impact on individuals’ travel behavioral changes caused by the external variables of government policies, social influences, their ownership of vehicles and bikes, this chapter will summarize the findings from the literature review to support author’s choices in these external variables.

Countries in the world have different control strategies to deal with Covid-19 outbreak, and they had caused changes in individuals’ travel behavior. In China’s case, the government enforced strict lockdown policies of “*case isolation, travel restrictions, closing*

*recreational venues, and banning public gatherings*”<sup>6</sup> starting from Wuhan city on January 23<sup>rd</sup>, 2020<sup>7</sup>. Such policy then quickly been adopted to other cities around the country, which did have immediate consequences on the reduction of individuals’ travel frequency reduction and all sorts of transportation methods in general.

In India’s case, the government also enforced its first lockdown starting from March 24<sup>th</sup>, 2020<sup>8</sup>. The perceived as “lower Covid-19 infection risk”, personal mode of transportation, its total utilization rate has increased. Yet the perceived as “higher Covid-19 infection risk”, shared mobility, its total utilization rate has decreased<sup>9</sup>. The higher-income group has the ability to avoid public transport, taxi, and other mass transport, while the lower-income group had no other options but to rely on public transport for daily commute<sup>10</sup>. In total, walk and bicycle has a 22% of growth rate, and the demand and willingness to pay extra for a safer, faster, cleaner, comfortable, and resilient public transport exists<sup>11</sup>.

The changes in travel behavior can be influenced by the surrounding greatly. Therefore, it is also important to investigate the sources of information that formed individuals’ risk attitudes towards each transport method. This result could help us to promote sustainable transportation in the most suitable way and reduce possible biases.

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<sup>6</sup> Huang Et al. *Understanding the Impact of the COVID-19 Pandemic on Transportation-related Behaviors with Human Mobility Data*. (2020)

<sup>7</sup> BBC News. 時間軸：武漢「封城」的 76 天

<sup>8</sup> P. Pulla. *Covid-19: India imposes lockdown for 21 days and cases rise*. (2020)

<sup>9</sup> Gajendran. *Impact of novel Coronavirus (COVID-19) pandemic on travel pattern: A case study of India.* *Indian Journal of Science and Technology*. (2020)

<sup>10</sup> Gajendran. *Impact of novel Coronavirus (COVID-19) pandemic on travel pattern: A case study of India.* *Indian Journal of Science and Technology*. (2020)

<sup>11</sup> Thombre Et al. *"A paradigm shift in urban mobility: policy insights from travel before and after COVID-19 to seize the opportunity."* (2020).

In Li (2020)'s paper, the research result shows that people's risk judgments are often fallible partly due to media biases. Li's team conducted two surveys. One is asking Wuhan and Sapporo residents about their opinions on any Covid-19 information they received from different resources. This survey is to test the reliability of received information for residents. Another survey is about the perceived risk of Covid-19 and travel intention in the future. This survey helped the researchers to understand how long the negative impact and biased impression will last.

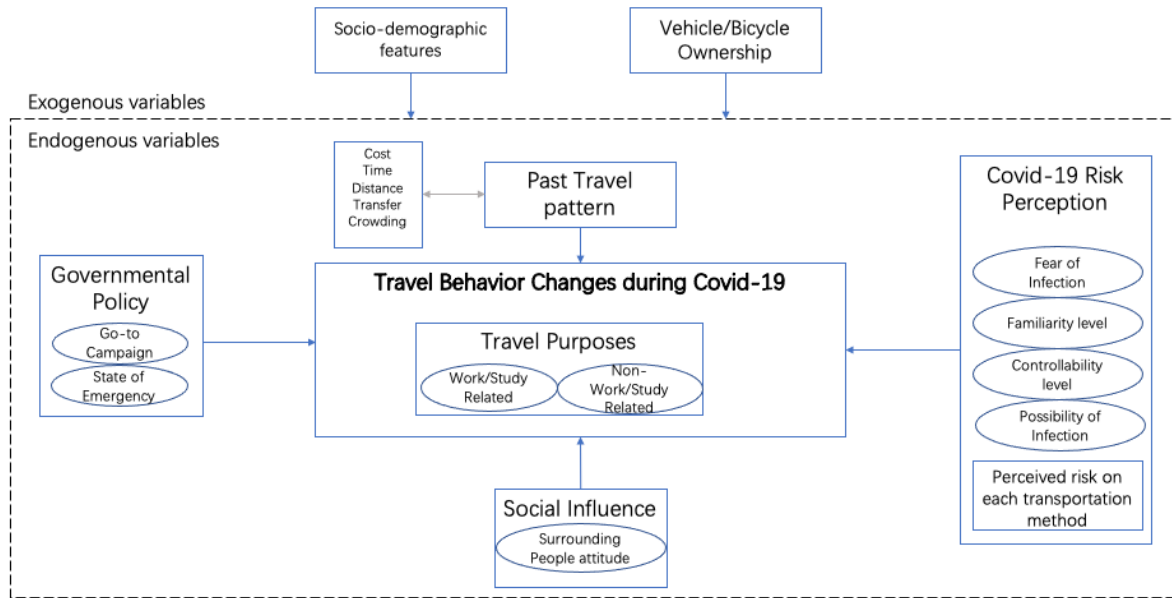
Interestingly, Zhang (2020) shares a similar point of view. He indicated that in Japan's case, the February 28<sup>th</sup> announcement of school closures by the central government was the biggest trigger to bring about behavioral changes against the spread of Covid-19. Zhang's team used the SEM analyses to reveal that recommendations from respondents' close social network members (family, colleagues, acquaintances, and friends) are most useful to bring about expected changes in life, among the factors of "reliability of information", "risk perceptions", and "attitudes" as well as "triggers of behavioral changes".

## **CHAPTER III: METHODOLOGY**

### **(1) Framework**

Based on the literature review results, the main variables affecting the travel behavior changes are: covid-19 risk perception, governmental policies, past travel patterns, social influence, vehicle ownership, travel purposes, educational level, psychological issues, environmental awareness, financial status, and accessibility. In this paper, the following variables will be covered: covid-19 risk perception, governmental policies, past travel patterns, social influence, vehicle ownership, and educational level. However, other popular

factors such as psychological issues, environmental awareness, financial status, and accessibility will not be included in this paper, the reasons will be elaborated in the interview results section. To have an overall picture, the below conceptual framework will be used to explain the relationships between variables.



*Graph 3: Conceptual Framework, made by author*

[Covid-19 Risk Perception] To better understand this latent variable and increase its validity and reliability, this paper will access it from five perspectives. Fear of infection, Familiarity level, the possibility of infection, and the perceived risk of each transportation method.

[Governmental Policy] As the impact of the Covid-19 pandemic, the tourism industry, in general, falls out of favor, and many countries that rely heavily on tourism are on the path to revitalizing their economy. In Japan's case, as the government attempts to stimulate the national economy by enforcing go-to-campaign policies, many people blamed this action for wasting their tax money. However, a number of people still actively using the campaigns due

to the bargain price.

[Past Travel Pattern] The importance level of cost, time, distance, transfer times, and crowdedness will be used to compare with the importance level of risk of being infected by Covid-19.

[Social Influence] How much does surrounding people's attitude influence individuals' conception towards Covid-19, and the comparison between individuals and their surroundings' attitude towards covid.

## **(2) Secondary Data analysis**

In Japan's case, after confirming the first patient who are infected by Covid-19 virus in Kanagawa prefecture on January 16<sup>th</sup>, 2020<sup>12</sup>, Prime Minister Shinzo Abe enforced its first State of Emergency Declaration from April 7<sup>th</sup> 2020 to May 25<sup>th</sup> 2020<sup>13</sup> to serve the purposes of to lessen the frequency of going out and decrease the infection rate. During the first State of Emergency Declaration, the confirmed cases decreased from 368 people per day to 21 people per day<sup>14</sup>. In Kashiwa city's case, the confirmed cases decreased from 10 people per week to 0 people per week<sup>15</sup>. However, the Japanese government, Ministry of Land, Infrastructure, Transport and Tourism then issued another policy called "Go-to Travel Campaign" starting from July 22nd 2020<sup>16</sup>, and temporarily postponed on December 22<sup>nd</sup> 2020<sup>17</sup>. Similarly, the Ministry of Agriculture, Forestry and Fisheries issued policy called

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<sup>12</sup> WHO, *COVID-19 - Japan - (ex-China)*. (2020)

<sup>13</sup> Cabinet Secretariat. *新型コロナウイルス感染症緊急事態宣言の概要*.

<sup>14</sup> NHK. *日本国内の感染者数*.

<sup>15</sup> Kashiwa City. *柏市新型コロナウイルス感染症データサイト*

<sup>16</sup> Ministry of Land, Infrastructure, *Transport and Tourism*. *Go To* *トラベル事業関連情報*.

<sup>17</sup> Go To *トラベル*. *Go To* *トラベル事業の一時停止等に係るキャンセルのご案内について*.

“Go-to Eat Campaign”, started from October 1<sup>st</sup> 2020 and temporarily postponed by November 24<sup>th</sup> 2020<sup>18</sup>. This policy serves the contradicting purposes of encouraging citizens to have leisure outside, and travel more frequently in order to stimulate the national economy. During the Go-to Campaign, the confirmed Covid-19 cases increased from 795 people per day to 2694 people per day. In Kashiwa city’s case, the daily confirmed cases increased from 13 people per week to 70 people per week.

For the secondary data analysis, I used the Google Mobility Trend Report (GMTR) and the Apple Mobility Trend Reports (AMTR) as the major source of data collection. AMTR reported changing trends in the number of people using cars, transit, and walking, by using route guidance request data. GMTR showed time series of trends in some locations such as entertainment facilities, stores, and public transportation by using GPS data from Smartphones. Indicating Point of Interest (POI). I also collected the secondary data published by the government about the daily confirmed cases in Japan and compare it with the impact of governmental policies as shown in the result section. I compared the number of confirmed patients, the governmental policy publishing time period, and compare them with the data from AMTR and GMTR, to investigate the connections.

### **(3) Interview and MAXQDA Coding**

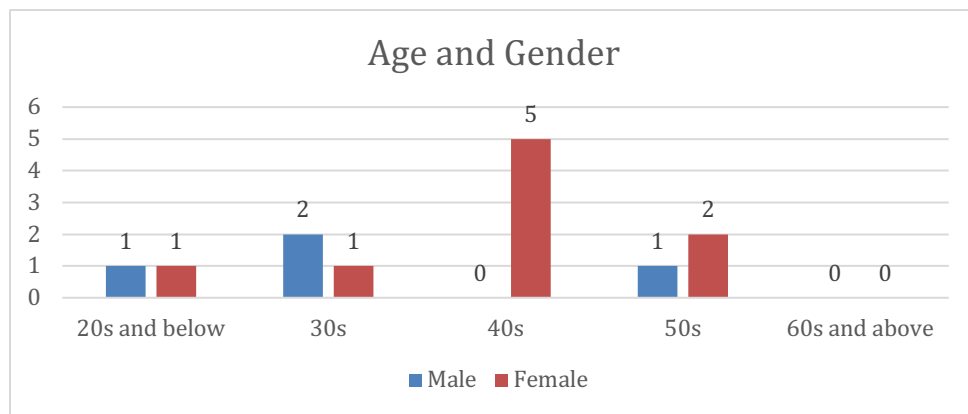
In order to understand Objective Two (Analysis of the risk perception for each sustainable transportation method) and Objective Three (Estimate the influence of each variable on travel behavior changes) in my study, I interviewed 13 residents living in Kashiwa city, and the interview time lasts around half an hour to 1 hour. It is a questionnaire-based

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<sup>18</sup> Ministry of Agriculture, Forestry and Fisheries. 「Go To Eat キャンペーン事業」について

interview and I used the snowball technique to reach out to my interviewees. The interview was conducted mainly in Japanese, and only 2 interviewees answered in English. The form of the interview was completed both online and in person.

In this paragraph, I will introduce the profile information of my interviewees. The questions of socio-demographic features of the interviewees included their age, gender, occupation, residential area, and the amount of time they spent living in Kashiwa city. The age and gender of my interviewees could be seen in the below Graph 4. The occupation of my interviewees could be seen in the below Graph 5. I will elaborate the details of each interviewee in the following paragraphs.



*Graph 4: Age and Gender of the interviewees, made by author*



*Graph 5: Occupation of the interviewees, made by author*

The first interview was conducted on October 5<sup>th</sup>, 2021. The interviewee is a male named K-san, in his 30s and temporarily working for the children's English education. The distinguishing feature of this interviewee is that he is the only one who changed his sense of environmental awareness during the pandemic. The reason is that he had the opportunity to meet students who majored in environmental science during this period, and was influenced by them. This impact is changing his perceptions when choosing a transportation method. K-san is planning to purchase an electronic vehicle in the future because by doing so, he could contribute to lowering carbon dioxide and slowing down global warming. In terms of risk perception, he considered shared mobility as extremely low risk due to the trust in the staff.

The second interview was conducted on October 7<sup>th</sup>, 2021. The interviewee is a female, named W-san in her 40s. In terms of risk perception, she believed that Kashiwa city is not a safe place, because it is close to Tokyo. A lot of people work and study in Tokyo, but live in Kashiwa, such as her son. W-san was afraid that these people will bring the virus back from Tokyo to Kashiwa through their commuting. Also, when determining the prioritization of choosing a transportation method, W-san said that if the daily infected patients are higher than 1,000 cases, she prioritizes the risk of Covid-19 infection the most. If not, she prioritizes the commuting time the most. In addition, she thinks that the fear of infection is closely connected to her knowledge of Covid. During the pandemic, her ways of spending also changed greatly, instead of traveling, she started to buy luxurious food such as beef tongue and used this as an alternative solution to deal with her stress.

The third interview was conducted on October 12<sup>th</sup>, 2021. The interviewee is a female named M-san in her 40s. She has lived in Kashiwa city for 14 years. She learned about environmental protection in her work. Every time when she goes outside, she will try to use

her own bag instead of plastic bags. She feels a little bit stressed out during the pandemic, because she can not go outside to meet her friends. In term of social influence, she thinks it is hard to quantify her surroundings' attitude since their attitudes toward Covid are so different. After the pandemic, she will utilize more transportation because she wants to travel.

The fourth interview was conducted on October 13<sup>th</sup>, 2021. The interviewee is a male, named C-san in his 30s. He has been living in Kashiwa city for 7 years since when he was an international student from China. During the pandemic, he utilized less public transportation (train) because of remote work. There are fewer needs for him to go outside. When the first State of Emergency was declared in April 2020, he was nervous and will intentionally avoid public transportation. But after the emergency declaration was released, he doesn't care much about the Covid pandemic until now. Even during the Tokyo Olympic games period, when there are more than 2,000 patients were confirmed daily, he still went to the Kansai area (Okayama) for travel. Because he thinks the Kansai area will be safer than Tokyo. In terms of perceived risks of each transportation method, he believes that a shared car is riskier than a shared bike. He also believes that the infection risk is strongly linked with population density. In his words, the train is not risky now since most people stayed home for remote work, and there are fewer people using the train. He also thinks that Kashiwa is safe because it is the furthest commuting city to Tokyo. It is a marginal commuting city.

The fifth interview was conducted on October 19<sup>th</sup>, 2021. The interviewee is a female, named A-san in her 30s. She just recently moved to Kashiwa city from Tokyo around 1 and half years ago. She lived near Kashiwanoha area, and the main reason holding her back from using the train is because of the expensive price for Tuskuba Express train. A-san is not familiar with the environmentally friendly transportation concept, but she cared a lot about

the ocean and marine life and global warming. During the pandemic, she feels stressed since there are no other places that her children can go except park. She was constantly worried about the noises because her kids are loud, and they are indoor most of the time during the pandemic. Before Covid, she can go out to have lunch and tea with her friends often, but during covid, they can't do that anymore. Her style of work and education also changed. The environment overall changed a lot, and it is difficult for her to adjust to the changes. A-san also thinks that achieving a work-life balance is difficult. For example, her husband will have to accompany the kids and help them with their homework after he finished working every day. So, her husband also sleeps late and didn't rest well. For the changes occurred during the pandemic, she thinks continuing disinfection and washing hands are nice things to do, but she will not continue wearing a mask, since the amount of carbon is not good for human body. The reason for her to maintain a high frequency of going outside, is because her children are still young. It is important for them to go outside and get some sunlight. Otherwise, they might get weird. Although she is afraid of Covid, but it is important to keep a balance. In term of Covid infection risk, A-san thinks everywhere can possibly get affected by Covid. It all depends on how many people are there, and the number of people who go to Tokyo for work. She tried to have a normal life and find the meaning of her heart. She thinks if people do not feel well emotionally, then they could get sick physically. In term of social influence, her husband perceives Covid-19 same as her. But in her surroundings, there are people do not afraid of Covid at all. There are also people who are terrified and would not leave their house. But many families who are also raising kids like her, feel the same way as she does, the number of people in a place is an important factor for them to decide to go or not to go.

The sixth interview was conducted on October 19<sup>th</sup>, 2021. The interviewee is a female,

named M-san in her 50s. She has been living in Kashiwa city for 23 years. She is relatively satisfied with the transportation in Kashiwa city, she thinks it is convenient. For trains, there are Tsukuba Express and JR Line, which is convenient to go to Tokyo. The bus is also convenient. she also has a car. In term of environmental protection and sustainability, she answered that she likes nature, and she has a bird. She thinks keeping a nice environment in the residential area is important. She also put efforts on classifying the trash and properly dealing with the used oil. During the Covid-19 pandemic, due to remote work, she is able to spend more quality time at home with her family. She also has time to cook more. However, she does not see her friends as much as she used to. Meanwhile, she cared more about physical strength and spent more time walking, around 1 hour per day, the longest can go up to 2~3 hours. She also realized that she could work at home. It is not necessary to commute to the workplace.

The seventh interview was conducted on October 20<sup>th</sup>, 2021. The interviewee is a female, named I-san in her 20s. She lived in Kashiwa city for 21 years. She thinks the transportation in Kashiwa city is convenient because there are a lot of buses. It is also easy to commute to Tokyo. She has more time to read books during Covid about the surroundings, cultures, and Covid-related issues. Her friends and herself made an effort not to use plastic when shopping. She was also able to spend a lot of crucial and priceless family time. She has time to do other things she enjoys. Even after Covid, she believes she would keep using disinfection. And practice yoga more frequently, as it helps her to relieve stress and tension.

The eighth interview was conducted on October 20<sup>th</sup>, 2021. The interviewee is a male, named D-san in his 50s. He lived in Kashiwa city for 43 years. In term of environmental protection, he consistently classifies rubbish. He is really concerned about climate change and

natural calamities, like the Amazonian rainforests. During the covid epidemic, this environmental awareness remained constant. After the Covid pandemic, he would keep using masks and cleaning. He will also make an effort to walk longer distances than before for the sake of his physical wellness.

The ninth interview was conducted on October 21<sup>st</sup>, 2021. The interviewee is a female, named Y-san in her 50s. She lived in Kashiwa city for 11 years. She thinks the TX is convenient but too expensive. The bus is also convenient. She only steps outside when it is absolutely necessary. During the pandemic, she had less possibilities of leaving the house. She only sees her friends around twice a month on average. She was always alone at home, and her mental health is poor. It's too silent for her. She needs more light. She played some games on Switch and other indoor sports for her physical fitness. She also intends to continue doing this during the post-pandemic period, since it is enjoyable. She won't be using disinfection, though, because it hurts her hands. She is unsure if she will wear a mask after that or not.

The tenth interview was conducted on October 23<sup>rd</sup>, 2021. The interviewee is a male, named S-san in his 20s. He lived in Kashiwa city for 13 years. According to him, the transportation near Kashiwa station and Kashiwanoha campus station are good. They are convenient due to the trains. However, he doesn't use the bus in Kashiwa city. He doesn't care too much about the environment, but has nothing against it neither. Just normal feeling. He emphasized that they needed to wear masks to class. Mentally, he feels content for having spent more time alone and reflecting throughout the pandemic. But he also has occasional anxiety. Due to the likelihood that they will contact or utilize Zoom frequently, he doesn't worry too much about catching up with his friends. He won't use a mask after covid, but he

will keep using disinfection.

The eleventh interview was conducted on November 4<sup>th</sup>, 2021. The interviewee is a female, named Y-san in her 40s. She lived in Kashiwa city for 8 years. She thinks the transportation in Kashiwa city is not so convenient. Trains are ok, but the buses do not come on time. She feels unsafe about the bus schedule. She also feels that Kashiwa city government does not have good countermeasures for Covid. She saw news such as babies died from covid. And Kashiwa city is pretty big place. She began using Zoom meetings throughout Covid, spending more time at home, and developing a preference for staying in. In contrast to going outside and using various modes of transportation both before and during Covid, she prefers to stay at home. After covid, if she had the option, she would like to carry on working remotely. She had no idea that she could work from home before discovering Covid, but Covid has helped her to understand that she can. She is aware that she has to exercise because she is unable to go outside. She was taking training sessions on Zoom three times a week for this reason. She also likes to go outside in the morning to walk her dog, since there will be less people, and she can take off her mask.

The twelfth interview was conducted on November 10<sup>th</sup>, 2021. The interviewee is a female named Y-san in her 30s. Every time she goes grocery shopping, she uses her own bag. She rarely discusses environmental concerns with others in her immediate vicinity. She solely speaks to her children and instills values such as "the fish are so pitiful, so don't dump the trash around" in them. Or, "if consuming excessive amounts of electricity, it is a burden for the environment and causes global warming." However, all of her children simply said "ok." They don't really talk about it much because even when she talks to her spouse, he just responds with "really." When she speaks with her friends, they discuss "Eco-bag," but they

only discuss the brand of the bag and not whether or not they should use eco-bags to protect the environment. She is surrounded by mothers at this stage of her life, and they only talk about children. Her career is also not doing very well. As a result, they rarely discuss other subjects, such environmental problems. The kind of environmental protection she will do, are very minor things. Such as picking up the trash etc. She thinks responsibility means something heavy and means that you have to reach out to other people and ask them to do the similar thing. But she will take responsibilities for the small things that she can do in daily life.

The thirteenth interview was conducted on December 14<sup>th</sup>, 2021. The interviewee is a female, named N-san in her 30s. She lived in Kashiwa city for 5 years. She thinks trains in Kashiwa city are convenient, because she lives near the station, and there are no pedestrian crossing for my kids, it is convenient for them to go to the station. But the Tsukuba Express train is a little bit expensive. The expensive price is a shortage, but it is convenient overall. Before she own a vehicle, she always takes the bus to Kashiwa station. But the bus schedule is not frequent, and the amount of time it takes to Kashiwa station is too much. Therefore, after she had a vehicle now, she doesn't use bus often. Sustainable transportation was something she had never noticed or paid attention to. When she watched TV, Yahoo News occasionally displayed environmental news. such as global warming, marine life, etc. She believes there is no use in classifying them at the outset for the local governments if they lack the capacity to handle the classified rubbish; instead, she can simply combine everything. Even if it is not needed, the government will categorize the trash if it can properly handle the classified waste.

#### **(4) Questionnaire and Regression Model Analysis**

##### **a. Questionnaire Design**

Due to the restrictions of the Covid-19 pandemic, most of the questionnaires in the field were conducted in the form of online surveys only. However, to have more inclusive results and avoid biased situations, people who cannot access the internet or do not understand the online questionnaire method will also be included, this study distributed questionnaires through mail delivery. To make sure that all the residential areas in Kashiwa city were included in the survey, my fellow friends and I distributed questionnaires in the most populated regions in Kashiwa city. In detail, 1050 copies of questionnaires were distributed around the major train stations (Kashiwatanaka station, Kashiwanoha station, Kita-Kashiwa station, Kashiwa station, Shin-Kashiwa station, Toyoshiki station, Masuo station, Sakasai station, and Takayanagi station), and 450 copies of questionnaires were distributed in the two most populated residential areas that were not nearby to any train stations.

To make the response process easier for the respondents, I included a QR code for the online version of the questionnaire as well. In another word, the respondents could choose to answer the questionnaire online through Google Form or fill out the paper questionnaire and mail it back to me. In total, I distributed 1,500 questionnaires through mail delivery, and the results I collected are 92 online questionnaire responses and 235 paper questionnaire responses, and 327 total responses. The return rate of my questionnaire is 21.8%, higher than the average questionnaire's 10% return rate. The reasons for Kashiwa residents' high response rate could be due to the factors of a University-orientated society and their special sociodemographic features (such as higher age, and higher educational background) which lead to a higher acceptance rate of questionnaires and surveys.

In the questionnaire designed for this paper, there is a total of 25 independent variables containing sociodemographic features, past travel patterns, governmental policies influence, social influence, covid-19 risk perception, and the perceived infection risk level of each transportation methods. In order to better understand and investigate the dependence between all the above-mentioned independent variables at the same time, the author used a correlation matrix to determine the correlation coefficients between those independent variables. The abbreviations of the variables used by author could be seen in the below Table 1.

Table 1: Abbreviations of the variables

<b>VARIABLE</b>	<b>QUESTION</b>
<b>PTP1</b>	When choosing a transportation method, I care about the risk of being infected by Covid the most.
<b>PTP2</b>	When choosing a transportation method, I care about the cost the most.
<b>PTP3</b>	When choosing a transportation method, I care about the time the most.
<b>PTP4</b>	When choosing a transportation method, I care about the distance the most.
<b>PTP5</b>	When choosing a transportation method, I care about the transfer times the most.
<b>PTP6</b>	When choosing a transportation method, I care about the crowdedness the most.
<b>GP1</b>	I used Go-to Campaign a lot.
<b>GP2</b>	Go-to Eat Campaign stimulates my incentives to go out.
<b>GP3</b>	Go-to Travel Campaign stimulates my incentives to go out.
<b>GP4</b>	1st State of Emergency lowered my intentions to go out.
<b>GP5</b>	2nd and the following State of Emergency lowered my intentions to go out.
<b>GP6</b>	Quasi State of Emergency lowered my intentions to go out.
<b>RP1</b>	Covid Dread Level (I am afraid of being infected by Covid).
<b>RP2</b>	Familiarity Level (I don't know how to fight with Covid).
<b>RP3</b>	Controllability Level (I think Covid is hard to get over with).
<b>RP4</b>	Possibility of Infection 1 (I am easy to be infected by Covid).
<b>RP5</b>	Possibility of Infection 2 (My living region has low Covid infection risk).
<b>SI</b>	Surrounding people's attitude towards Covid changed my behavior.

To understand the correlation among all the independent variables, governmental policy, risk perception, past travel behavior, and social influence, I will be using R software to analyze the data based on the regression model. I will also be using R software to define the most influencing variables that effect the changes of each transportation utilization frequency, the frequency for individuals' travel purposes and frequency for going outside of Kashiwa city by using stepwise regression model.

#### **b. Data Screening**

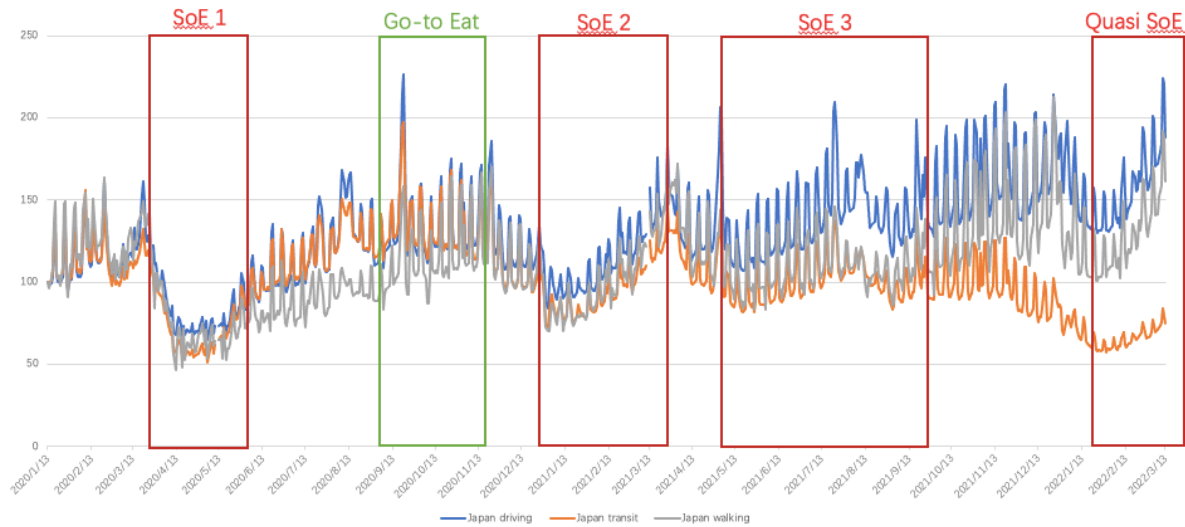
According to Hair et al.'s (2009) Rules of Thumb, "Missing data under 10% for an individual case or observation can generally be ignored". In my research, I have total 17,930 answers to the questions, the NA answers are 142. Therefore, the missing data is 0.79%. I will use the calculated replacement values, the mean of all the responses to the case, to fill in the missing data.

### **CHAPTER IV: RESULTS**

#### **(1) Secondary Data Results**

To understand how much governmental policies influence the travel behavioral changes in Japan, I collected the data from AMTR and made the below Graph 6. It shows how much does the searching of destination in driving, public transiting, and walking reduced during each time periods. For the time periods, "SoE1" represents the First State of Emergency Declaration, from April 7<sup>th</sup> 2020 to May 25<sup>th</sup> 2020. "Go-to Eat" represents the Go-to Eat campaign from October 1<sup>st</sup> 2020 to November 24<sup>th</sup> 2020. "SoE2" represents the Second State of Emergency Declaration, from January 8<sup>th</sup> 2021 to March 21<sup>st</sup> 202. "Soe3" represents the third State of Emergency Declaration from April 25<sup>th</sup> 2021 to September 30<sup>th</sup>

2021. “Quasi SoE” represents the Quasi State of Emergency Declaration from January 21<sup>st</sup> 2021 to February 13<sup>th</sup> 2021.



*Graph 6: Data from AMTR, graph made by author*

As the results from Graph 4 shown, the second and third State of Emergency Declarations do not result in any appreciable changes in travel behavior in terms of governmental policy. Given that the Covid-19 pandemic lasted a long time and that people's reactions fluctuated, asking them how they used each mode of transportation during the Covid-19 pandemic could be perplexing. In order to identify the specific changes, the author chose to solely compare the periods before to the COVID-19 epidemic and the first State of Emergency Declaration.

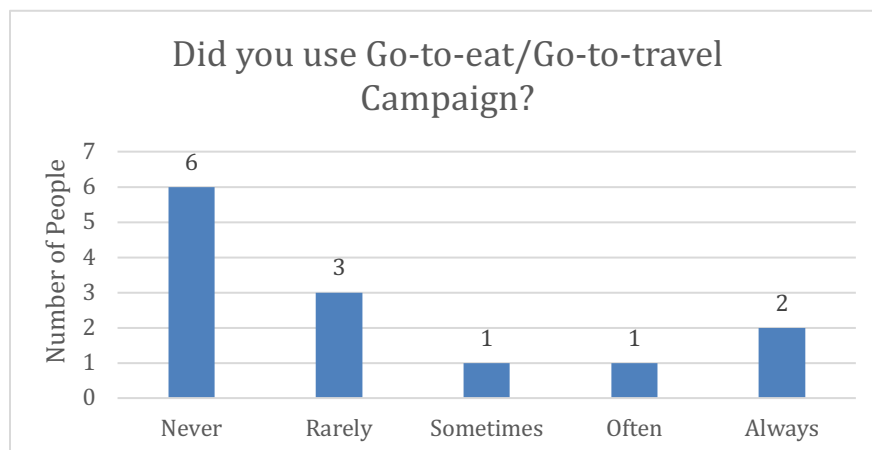
Also, during the Go-to Campaign, the travel frequency goes up, which indicates that such policy did stimulate individuals' incentives to go out. Such economic resurgence policy served an opposite purpose with the restriction policies State of Emergency Declaration. Which then leads to the question, how did these conflicting government policies influence

individuals' travel behavior choices?

Additionally, AMTR data only displays the frequency changes of the seeking routes, therefore the frequency changes of use may differ. In other words, it is vital to ask people about their actual changes in transit frequency. Additionally, AMTR only offers driving, taking public transportation, and walking as modes of transportation. It failed to distinguish between buses and trains and left out other environmentally friendly transit options such as biking and shared mobility. The detailed perception and utilization of each mode of transportation must therefore be further investigated.

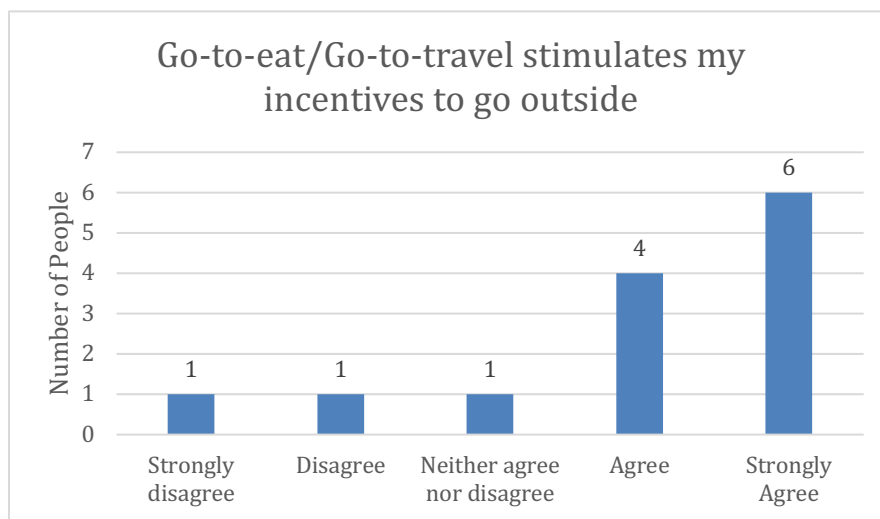
## (2) Interview Results

The below Graph 7 showed the results of interviewees' answers to the question: Did you use Go-to-eat or Go-to-travel Campaign. There are 6 interviewees who never used it, 3 interviewees rarely used it, 1 interviewee sometimes use it, 1 interviewee often use it, and 2 interviewees always use it. As a result, nearly half of the interviewees have the experience with using Go-to Campaign. And there are some of them not using Go-to Campaign because they are not familiar with the process. If all the interviewees were familiar with the process, the result of usage would suspect to be higher.



*Graph 7: Data from Interview, graph made by author*

The below Graph 8 showed the results of interviewees' answers to the question: Did Go-to-eat or Go-to-travel Campaign stimulates your incentives to go outside. There are 6 interviewees who strongly agree, 4 interviewees agree, 1 interviewee remains neutral, 1 interviewee disagrees, and 1 interviewee strongly disagrees. As a result, go-to campaigns did stimulate individuals' incentives to go outside during covid restrictions. However, interviewees have different viewpoints for Go-to-Eat and Go-to-Travel campaigns. Therefore, in the latter questionnaire research, I will ask Go-to-Eat and Go-to-Travel campaigns separately.

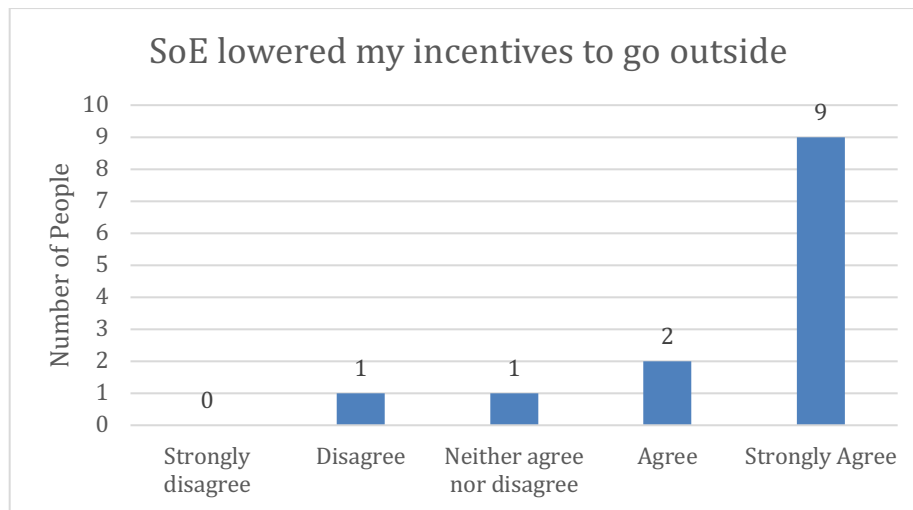


*Graph 8: Data from Interview, graph made by author*

For the interview results on Go-to Campaign, the interviewees showed different attitudes. For example, those who selected strongly agree, and answered *"I used the campaign a lot before. After the first state of emergency in Japan was lifted, I used the go-to-eat campaign a lot of times...If the government is opening the campaigns again, I would actively*

*be using the campaigns.” Those who selected agree, their answer is “Normally, my family are not the kind of families who go to travel or go outside to eat often. However, when the price is low, we will consider it.” There are also interviewees do not know how to use the campaign, for example, “I didn’t use go-to-eat because I don’t know how it works. I didn’t go eat outside often either. If the system is easier, I might use it. For go-to-travel, I was worried about the Covid situation, and think it is a bit dangerous.” For interviewees who are against the campaign policy, their answers are “Both go-to-eat and go-to-travel did not make me want to go outside more. Because I know the infection risk is high. However, for people such as restaurant owners, such policies are necessary.”*

The below Graph 9 showed the results of interviewees’ answers to the question: Did the State of Emergency Declaration (SoE) lowered your incentives to go outside. There are 9 interviewees who strongly agree, 2 interviewees agree, 1 interviewee remains neutral, 1 interviewee disagrees, and 0 interviewee strongly disagrees. As a result, the state of emergency have no doubts lowered individuals’ incentives to go outside. From the feedback of my interviewees, it is also possible for them to feel less emergent without the SoE. For the interview results on the State of Emergency declaration, there are some respondents only feel different or alerted for the first State of Emergency. For example, *“At the first wave SoE, I was really afraid, and didn’t go outside at all. However, during the second and third wave of SoE, my way of thinking changed, and still went outside for grocery shopping.”* Also, *“I was scared for the first SoE, but not so much for the 2nd and 3rd time.”* For those interviewees, it is hard for them to answer the question of their utilization frequency during the pandemic.

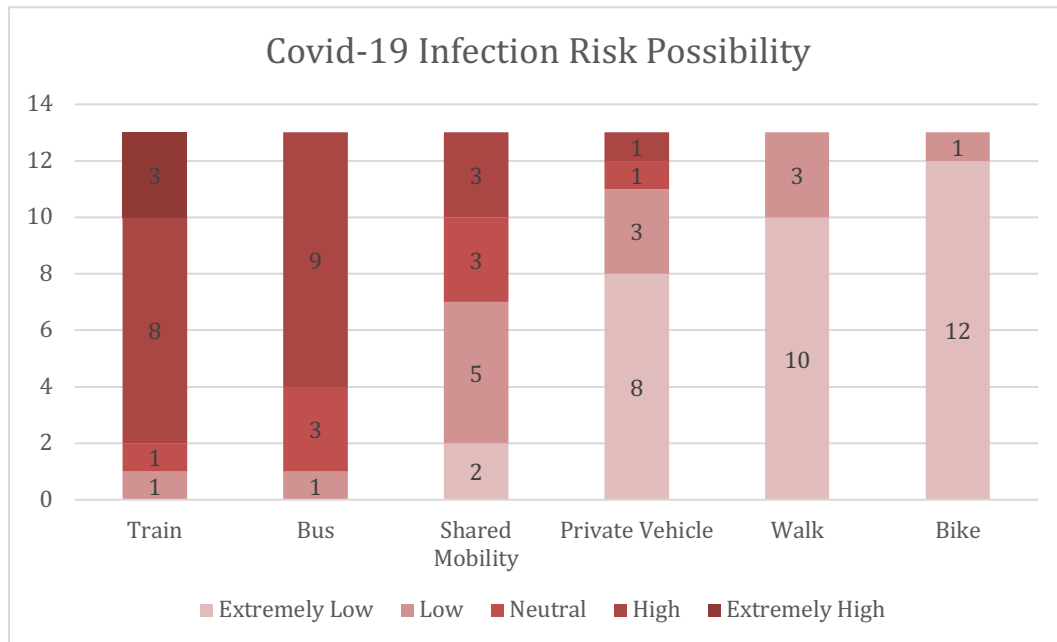


*Graph 9: Data from Interview, graph made by author*

For the interview results on the perceived Covid-19 infection risk of each transportation method, interviewees have different perception for them. For example, for the train, *“On the train, there are more people from outside of Kashiwa city.”* For the bus, *“On the bus, you must hold something. It is also crowded. I once got infected to the flu on the bus.”* For the shared mobility, *“Shared bike is OK. Shared vehicle’s case, it is possible that the previous user touched a lot of places. I am also uncertain about the disinfection for shared mobility.”* For the private vehicle, *“It is a small space, and we don’t disinfect the car often as the company does.”* For walking, *“If there are some people who try to talk to me when I’m walking, it is risking.”* For biking, *“I’m afraid that someone sneezed at me when I’m biking.”*

The below Graph 10 showed the results of interviewees’ answers to the perceived Covid-19 infection risk for each transportation method. As a result, Train apparently to be perceived as the transportation method with highest Covid-19 infection risk, then followed by bus, shared mobility, walking, and biking apparently to be perceived as the transportation method with the lowest Covid-19 infection risk. An interesting finding is that, 11 out of the total 13 interviewees have never used shared mobility before. Their evaluation for the infection risk

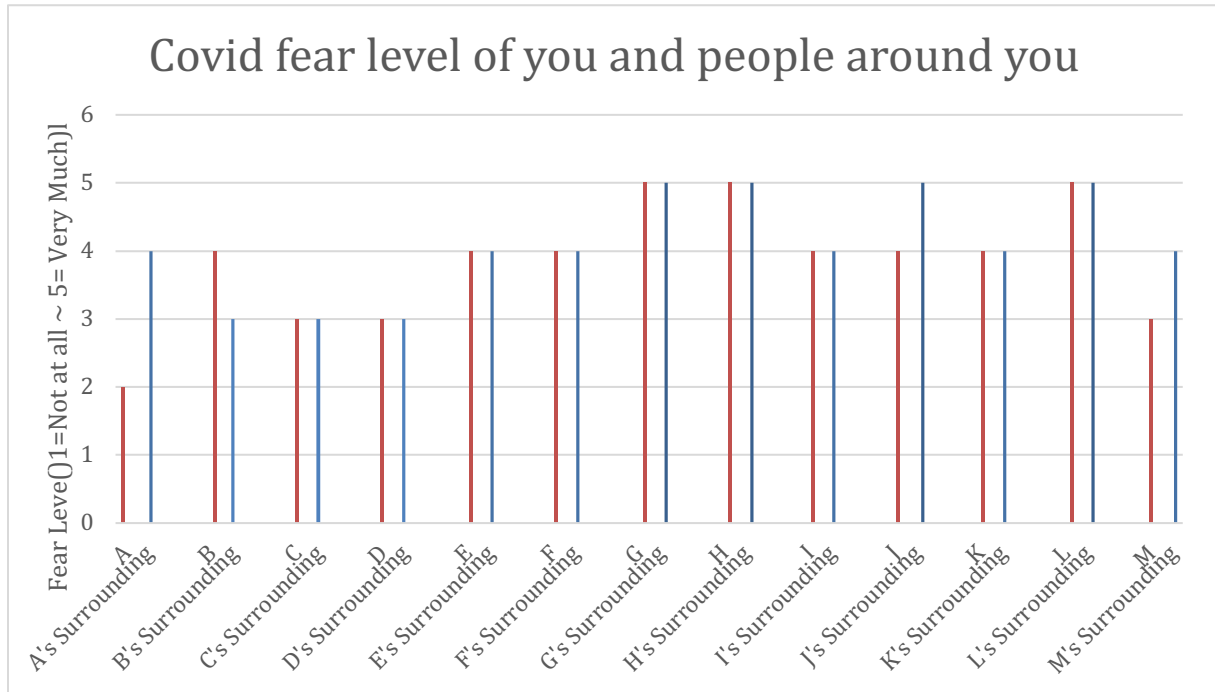
of shared mobility is depending on the disinfection. Lacking trust towards disinfection is the main reason holding people back from using shared mobility. Also, many of them answered that if the disinfection of shared mobility could be guaranteed, their perceived infection risk will get lower.



*Graph 10: Data from Interview, graph made by author*

In term of social influence, individuals' risk perception is not much influenced by others. The main reason is because their surrounding people hold different opinions towards Covid-19 infection risk, and it is hard for interviewees to answer the question about their surroundings. Therefore, when they select an answer for the question: how much your surrounding fear of does being infected by Covid-19, they tend to calculate an average answer in their mind, and only focus on the close family members and friends. Therefore, the results on the surroundings' attitude towards Covid-19 could not be a reliable data source. In the below Graph 11, it showed all 13 interviewees and their surroundings' fear towards being infected by Covid-19. Apparently, there is not much different between themselves and the

surroundings. X-axis represents the interviewee's and the interviewees' surroundings' attitude. Y-axis represents the fear level of being infected by Covid-19. Value 1 denotes *Complete lack of fear*. Value 2 denotes *A mild sense of fear*. Value 3 denotes a *Neutral state of fear*. Value 4 denotes *A modicum of fear*. Value 5 denotes *Extreme Fear*.



*Graph 11: Data from Interview, graph made by author*

Another interesting finding is that all interviewees who responded "enjoying quality time with family during Covid" are females. Female interviewees also tend to care more about their children and family's well-being during Covid than male interviewees. Especially parents of underage children tend to continue to go outside for their children during covid, for example, go to the piano lessons, plan camping trips, go to park activities and etc.

I also utilized the MAXQDA software to justify the variables of governmental policy, social influence, past utilization pattern, living region risk level, infection possibility, controllability of Covid-19, familiarity level with Covid-19, Covid-19 dread level, non-

work/study related travel behavior, work/study related travel behavior, Changes of information, attitude, values, and behaviors in my research, as shown in the below Graph 12.

代码列表	Kaz...	Wak...	Che...	Aya...	Mih...	Daic...	Iked...	Yagi...	Sho...	Yuki...	Nori...
Governmental policy					1	1	1	3	1	2	
Social Influence				1			1		2		3
Past Utilization pattern		1	1					1			
Covid-19 Risk Perception											
Kashiwa city risk level		1	1		1	1	1			1	2
Infection Possibility		1	1	1		1		1	2		
Controllability	1										1
Familiarity level		1					1				2
COVID-19 dread level			2						1		4
Purposes of Going out											
Non-work/study related behavior cl							2	1	1		
Work/study related behavior chang			1						1		1
Changes during Covid											
Information	2									1	
Attitude				2	1		1	2	1	1	
Value				2	1	1				1	
Behavior		1		2	1	1	2	2	1	1	

Graph 12: Data from Interview, graph made by author

From the analysis of the interview results, there are some variables that showed different results from the previous literature review. First, the environmental awareness. There are only 2 people out of 13 interviewees who associated their transportation method choices with their environmental awareness, and even for them, the connection between environmental awareness and their choices in transportation method seemed weak. The rest 11 interviewees found the questions about environmental awareness abrupt, and hard to answer. Therefore, I will not include the questions of “environmental awareness” in my questionnaire.

Second, the utilization frequency during Covid appeared to be difficult to narrow down to a specific time, since the utilization rate of each transportation method is relatively different during the State of Emergency and the rest, choosing one answer to represents the entire pandemic period appeared to be difficult. An interesting fact is that many people do not

perceive current situation as “during covid”. From their perspectives, current situation, around the end of 202 is considered as post-covid by my interviewees, as the situation is not as severe as the beginning in 2020. Clarify the time period would be necessary. Interview results showed great difference in transportation method utilization between the State of Emergency Declaration and the rest of time during Covid-19 pandemic. The interview finding on governmental policies showed a synchronous result on the significance impact of the State of Emergency Declaration with the secondary data analysis. Since most of the respondents’ Covid-19 risk perception level showed a significant difference between the State of Emergency and the rest time during pandemic, the questionnaire will only ask utilization frequency on each transportation method before Covid, and during the State of Emergency Declaration.

Third, in term of transportation methods, as the synthesis of findings from the secondary data analysis and the interview results, the Apple Mobility Trend Report only included transportation methods of “Driving, transiting, walking”, combined bus and train into transiting, and ignored shared-mobility and biking. However, the Interview results showed that individuals have different risk perceptions for each transiting method, and it is necessary to ask each transportation method’ utilization frequency and perceived risk separately.

Therefore, it leads to the conclusion that a larger scale of questionnaire data collection and analysis is necessary. To serve the purposes of (1) Understanding the perceived risk level for each sustainable transportation method. (2) The utilization frequency changes during the pandemic. (3) Evaluate the influence of each variable on individuals’ travel behavior changes.

### **(3) Questionnaire Data Results**

In order to have a better understanding of the respondents, a clear image of the sociodemographic features of respondents are necessary. First of all, the gender ratio of Male, Female, and unknown is 60:39:10. There are 194 male respondents, 128 female respondents, and 4 respondents who preferred not to answer this question. Second of all, the age difference between respondents is quite interesting. The ratio of people who are younger than 60 years old and the people who are aged 60 and above is 53:47. In specific, there are 19 respondents in their 20s; 32 respondents in their 30s; 53 people in their 40s; 50 respondents in their 50s, and 172 respondents in their 60s or above. Judging from these results, the average age of respondents in this questionnaire is 49 years old. Such results could be influenced by the aging population in Japan. Third of all, considering the average age of respondents, the occupation of employees and unemployment are the majority. In detail, there are 110 employees, 15 governmental servants, 20 self-employed respondents, 41 respondents doing part-time jobs, 3 students, and 136 respondents are unemployed. The last perspective in this research's socio-demographic features is the educational background. University graduates are dominant in the question. There is only 1 respondent who graduated from middle-high school, 80 respondents graduated from high school, 45 respondents graduated from Junior college, 166 respondents graduated from 4-year University, and 27 respondents have a final degree of Master and above. Based on these results, we could conclude that the average education level of respondents is relatively high.

Besides the general socio-demographic features, this questionnaire also included the following two questions at the beginning of the survey to have a better understanding of the changes in their travel behavior: their postcodes, and ownership of vehicles and bicycles. For the ownership of vehicles, there are two categories that the respondents could choose gasoline

vehicles or clean energy vehicles. The reason is to differentiate responses from the smart-city regions and non-smart-city regions, and also to indicate the amount of environmentally friendly transportation methods and non-environmentally friendly transportation methods available in the responses. For the results of ownership, gasoline vehicle and bike are the most chosen answers. There are 202 respondents who own a gasoline vehicle, 177 respondents who own a bike, 32 respondents who own a clean energy vehicle, and 21 respondents who selected the option of “none of the above”.

For the responses on living regions, I collected 27 different answers. The most popular answer is the Kashiwanoha region (post code: 277-0882) with 48 respondents, the following regions are the Wakashiba region (post code: 277-0871) with 41 respondents, the Omuro region (post code: 277-0813) with 32 respondents, the Toyofuta region (post code: 277-0872) with 21 respondents, the Matsugasaki region (post code: 277-0835) with 19 respondents, the Takayanagi region (post code: 277-0941) with 19 respondents, the Kaga region (post code: 277-0051) with 17 respondents, the Matsuba-cho region (post code: 277-0827) with 15 respondents, the Nedo region (post code: 277-0831) with 14 respondents, the Takata region (post code: 277-0861) with 13 respondents, the Toyoshiki region (post code: 277-0863) with 13 respondents, the Hananoi region (post code: 277-0812) with 12 respondents, the Akehara region (post code: 277-0843) with 10 respondents and etc.

For the second section of the questionnaire, I asked about their past travel pattern. In detail, I asked the respondents what they care about the most when selecting a transportation method. The purpose of this section is to understand, compare with other factors, how much individuals prioritize the infection risk of Covid-19 when they are selecting transportation methods. There are totally 6 statements in this section, they are: (1) When selecting a

transportation method, I care about the infection risk of Covid the most. (2) When selecting a transportation method, I care about the cost the most. (3) When selecting a transportation method, I care about the time the most. (4) When selecting a transportation method, I care about the distance the most. (5) When selecting a transportation method, I care about the transfer times the most. (6) When selecting a transportation method, I care about the crowding level times the most. The Likert scale was used in this case to measure the importance of each option, from strongly disagree, disagree, neutral, agree, to strongly agree. The result for (1) prioritization in Infection risk of Covid is 91 strongly agree, 95 agree, 46 neutral, 61 disagree, and 33 strongly disagree. The result for (2) prioritization in cost is 63 strongly agree, 115 agree, 69 neutral, 54 disagree, and 21 strongly disagree. The result for (3) prioritization in time is 119 strongly agree, 97 agree, 48 neutral, 16 disagree, and 5 strongly disagree. The result for (4) prioritization in Distance is 65 strongly agree, 104 agree, 87 neutral, 51 disagree, and 13 strongly disagree. The result for (5) prioritization in transfer times is 81 strongly agree, 121 agree, 64 neutral, 42 disagree, and 13 strongly disagree. The result for (6) prioritization in crowding level is 117 strongly agree, 127 agree, 43 neutral, 28 disagree, and 8 strongly disagree.

For the third section of the questionnaire, I asked about individuals' attitudes toward governmental policies. Such as the Go-to campaign and state of emergency declaration. The purpose of this section is to understand how much impact government policies have on individuals' travel behavior changes. I asked 3 questions about the Go-to campaign, they are: (1) I used Go-to-eat and Go-to-travel often. (2) Go-to-eat stimulated my incentives to go out. (3) Go-to-travel stimulated my incentives to go out. I also asked 3 questions about the state of emergency declaration. They are (4) First SOE decreased my incentives to go out. (5)

Second and following SOE decreased my incentives to go out. (6) Quasi-SoE decreased my incentives to go out. The Likert scale was used in this case to measure the importance of each option, from strongly disagree, disagree, neutral, agree, to strongly agree. The result for question (1) is 133 strongly agree, 21 agree, 7 neutral, 11 disagree, and 154 strongly disagree. The result for question (2) is 17 strongly agree, 45 agree, 60 neutral, 58 disagree, and 147 strongly disagree. The result for question (3) is 45 strongly agree, 63 agree, 47 neutral, 43 disagree, and 129 strongly disagree. The result for question (4) is 238 strongly agree, 49 agree, 22 neutral, 11 disagree, and 7 strongly disagree. The result for question (5) is 131 strongly agree, 132 agree, 37 neutral, 22 disagree, and 5 strongly disagree. The result for question (6) is 84 strongly agree, 123 agree, 57 neutral, 45 disagree, and 18 strongly disagree.

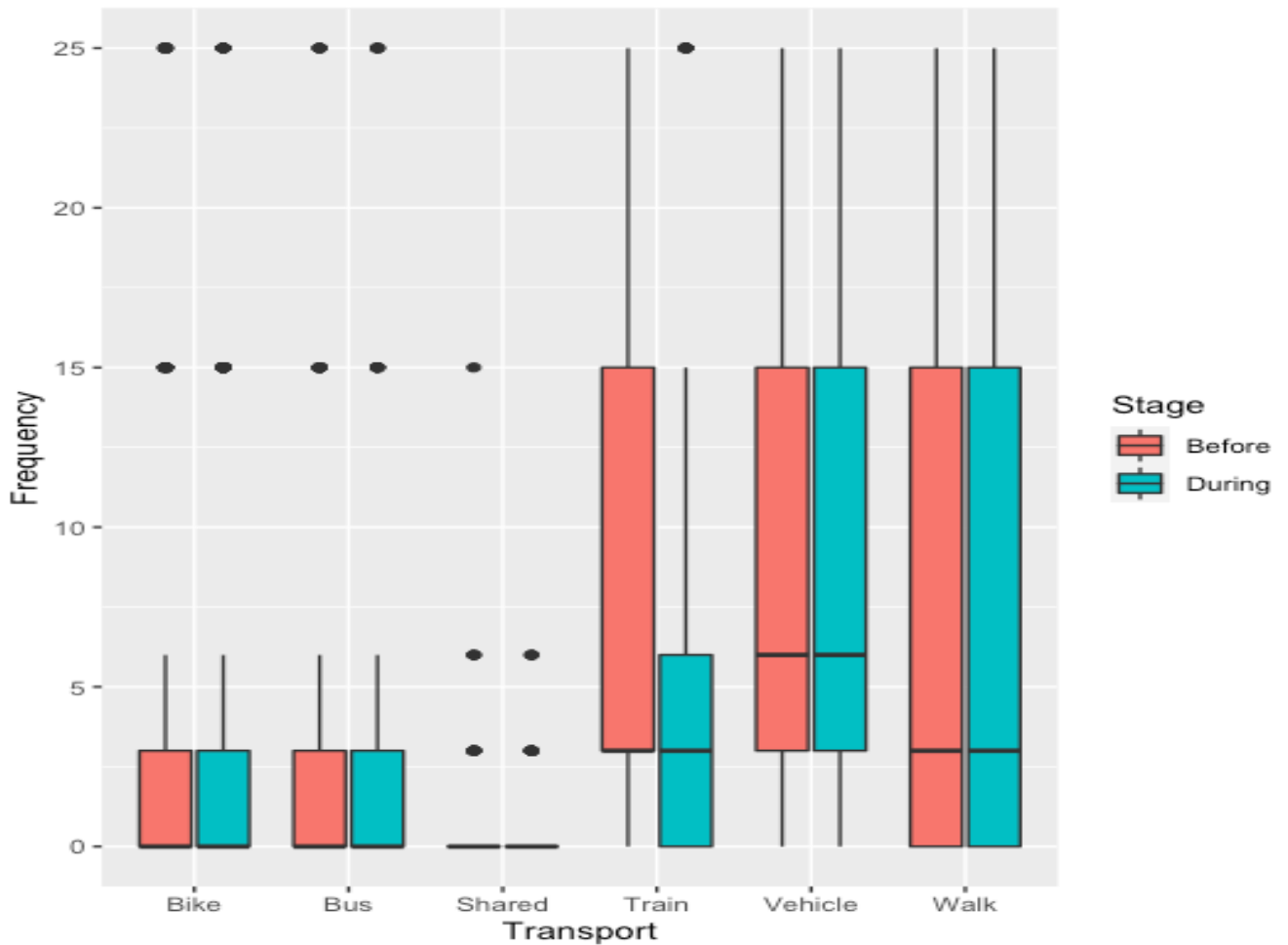
For the fourth section of the questionnaire, I asked about the Covid-19 risk perception and the social pressure to have a better understanding of respondents' psychological factors. In detail, I asked 6 questions, they are (1) Fear of infection: I am afraid of being infected by Covid. (2) Social Influence: Surroundings' attitude towards Covid affected my actions. (3) Familiarity level: I don't know how to fight with Covid. (4) Controllability level: I think it is difficult to get over Covid. (5) Possibility of infection: I think I'm easy to be affected by Covid. (6) Possibility of infection: I think the infection risk in my living area is low. The Likert scale was used in this case to measure the importance of each option, from strongly disagree, disagree, neutral, agree, to strongly agree. The result for question (1) is 175 strongly agree, 93 agree, 32 neutral, 23 disagree, and 4 strongly disagree. The result for question (2) is 68 strongly agree, 107 agree, 83 neutral, 44 disagree, and 24 strongly disagree. The result for question (3) is 6 strongly agree, 25 agree, 67 neutral, 135 disagree, and 92 strongly disagree. The result for question (4) is 17 strongly agree, 47 agree, 74 neutral, 129 disagree, and 69

strongly disagree. The result for question (5) is 9 strongly agree, 26 agree, 122 neutral, 114 disagree, and 56 strongly disagree. The result for question (6) is 19 strongly agree, 81 agree, 124 neutral, 68 disagree, and 35 strongly disagree.

For the fifth section of the questionnaire, I asked questions about the perceived risk level of each transportation method to understand the relationship between perceived risk level and the utilization frequency changes of each transportation method. In detail, the questions are (1) Walking has a high infection risk. (2) Biking has a high infection risk. (3) Private Vehicle has a high infection risk. (4) Shared Mobility has a high infection risk. (5) Bus has a high infection risk. (6) Train has a high infection risk. The Likert scale was used in this case to measure the importance of each option, from strongly disagree, disagree, neutral, agree, to strongly agree. The result for question (1) Walking has 5 strongly agree, 11 agree, 50 neutral, 158 disagree, and 102 strongly disagree. The result for question (2) Biking has strongly agree, 6 agree, 40 neutral, 145 disagree, and 128 strongly disagree. The result for question (3) Vehicle has 3 strongly agree, 10 agree, 37 neutral, 135 disagree, and 136 strongly disagree. The result for question (4) Shared-mobility has 11 strongly agree, 80 agree, 123 neutral, 79 disagree, and 28 strongly disagree. The result for question (5) Bus has 54 strongly agree, 144 agree, 81 neutral, 43 disagree, and 3 strongly disagree. The result for question (6) Train has 70 strongly agree, 147 agree, 73 neutral, 31 disagree, and 4 strongly disagree.

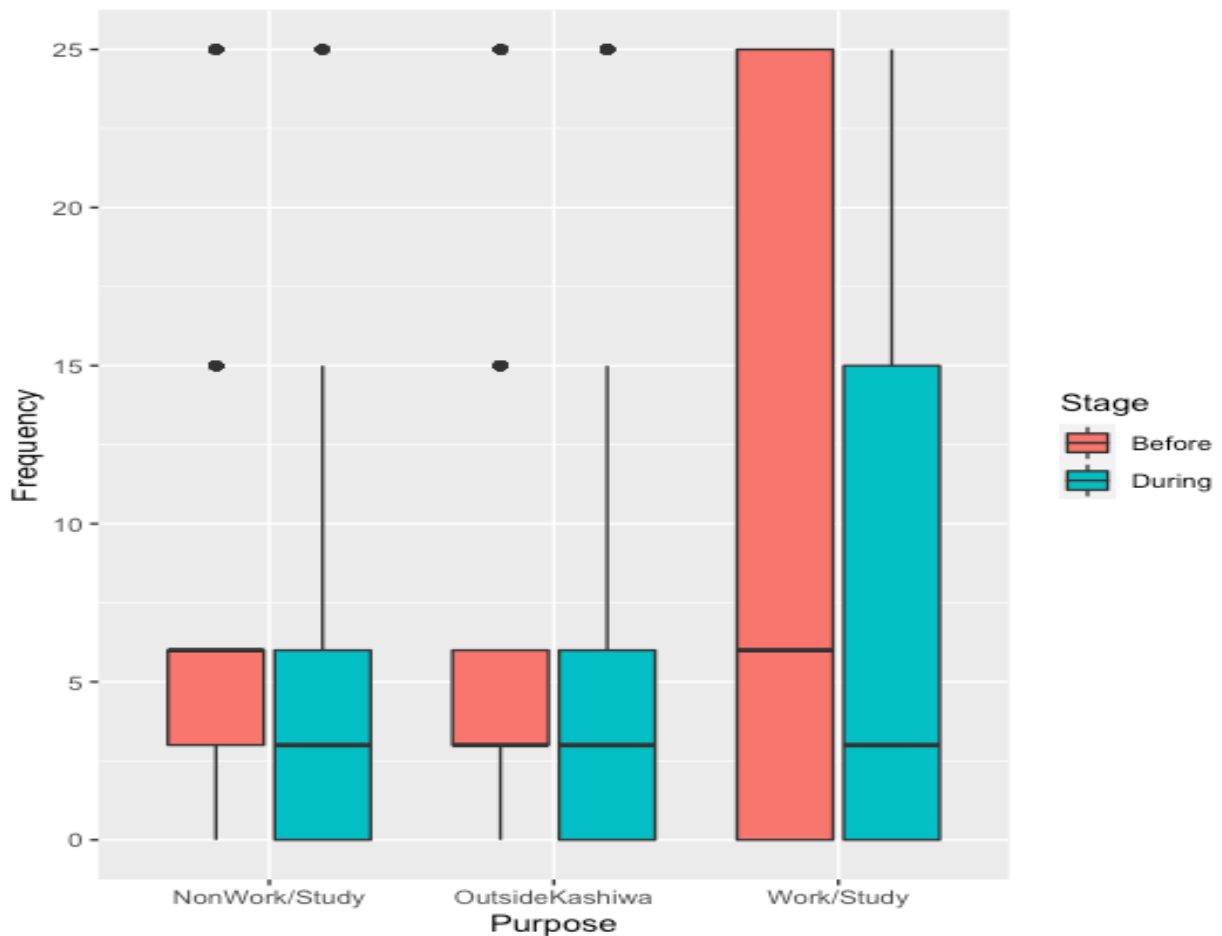
For the sixth section of the questionnaire, I asked about individuals' utility rate of each transportation method before the pandemic, and during the State of Emergency Declaration. The reason for asking these questions is to indicate the specific changes in each transportation method. The available options of utilization frequency are None, 1~3 days per month, 1~2 days per week, 3~4 days per week, 5~6 days per week, and Everyday. To have a visualization

of the results, I will use the Graph 13 below to present the results for this section.



*Graph 13: Data from questionnaire, graph made by author*

For the last section of the questionnaire, I asked about the changes of their travel purposes frequency before the pandemic and during the State of Emergency Declaration. The reason for asking these questions is to find out the connection between their travel purposes and travel frequency changes. The available options of utilization frequency are None, 1~3 days per month, 1~2 days per week, 3~4 days per week, 5~6 days per week, and Everyday. To have a straightforward understanding, I will use below Graph 14 to present the results for this section.



*Graph 14: Data from questionnaire, graph made by author*

In the below Graph 15, the blue color represents a positive correlation, while the red color represents a negative correlation. The larger the dots are, the stronger the relationship is. For example, in terms of RP1, GP4, GP5, GP6, Shared-mobility, bus, train, age, and SI had a positive correlation with RP1. In terms of RP2, vehicle, walking, biking, PTP2, and GP2 have a positive correlation with RP2, and GP1 had a negative correlation with RP2. In terms of RP3, RP4, RP2, RP1, Vehicle, walking, biking, shared-mobility, bus, train, PTP1, GP6, and SI had a positive correlation with RP3, while PTP2 and GP1 had a negative correlation with RP3. In terms of RP4, RP1, RP2, Vehicle, walking, biking, shared-mobility,

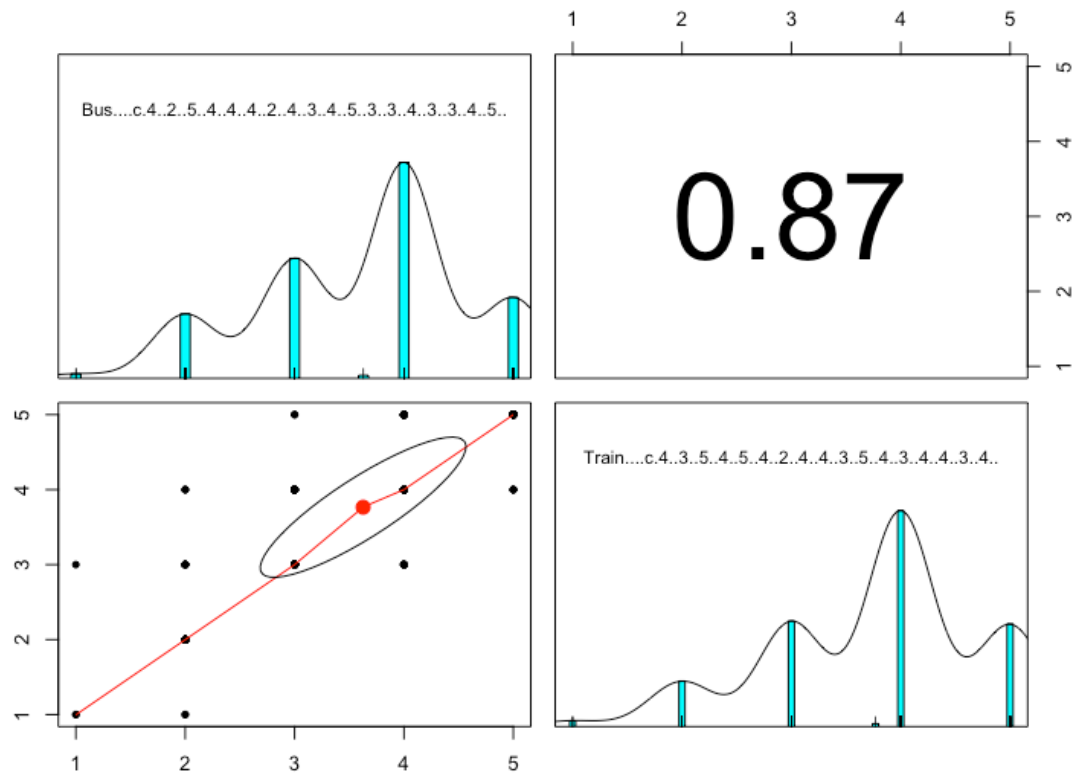


correlation. GP5 and GP6 (Quasi State of Emergency lowered my intentions to go out) had a high correlation. GP1 (I used Go-to Campaign a lot) and GP3 (Go-to-Travel stimulates my incentives to go out) had a high correlation. GP2 (Go-to-Eat stimulates my incentives to go out) and GP3 had a high correlation.

This then leads to the next step of justifying the necessity to keep those high correlated variables in the next step of the stepwise regression model. Since all these above independent variables are questions asked on the Likert scale from strongly disagree to strongly agree, they should be measured as ordinal variables. The author used Spearman's rank correlation coefficient, as the formula is shown in the below graph, to assess the relationship between every two variables mentioned previously.

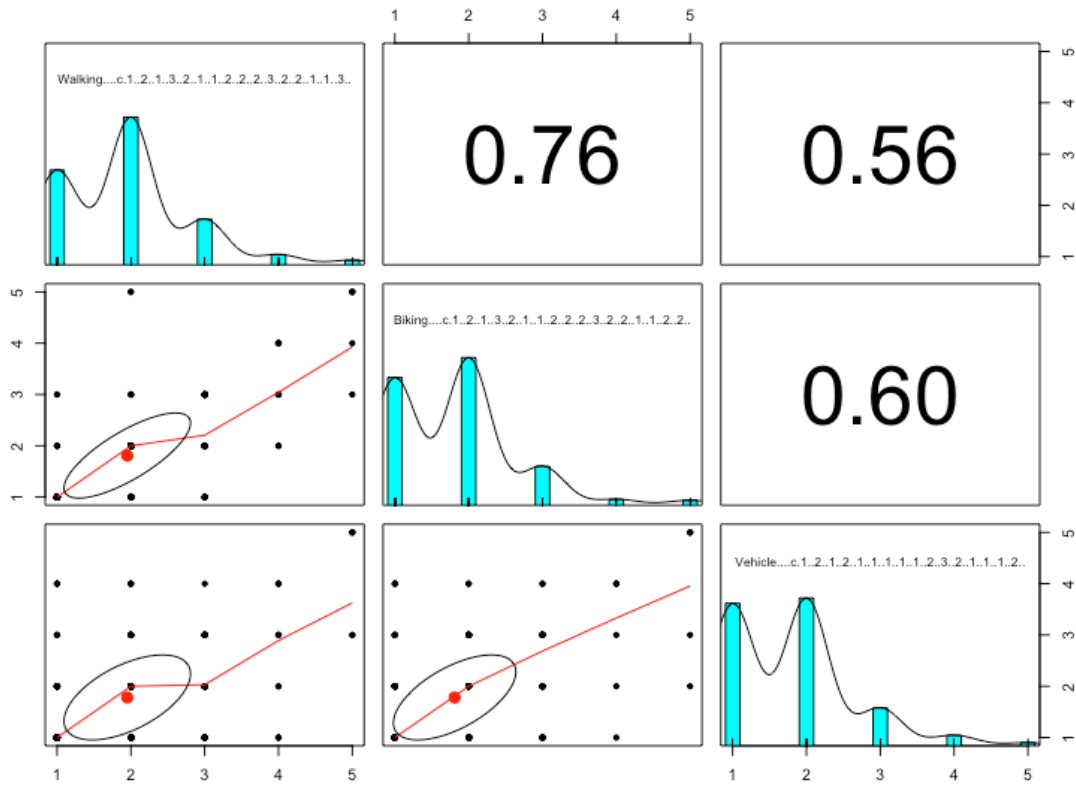
$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

The Spearman's rank correlation coefficient of perceived Covid-19 infection risk on buses and trains is [0.854122]. Bus and train were perceived to have a high correlation. I also ran the Pearson correlation coefficient and the result was shown in the below Graph 16, the bus and train has a high correlation value of 0.87. Therefore, we should only choose one to represent them.



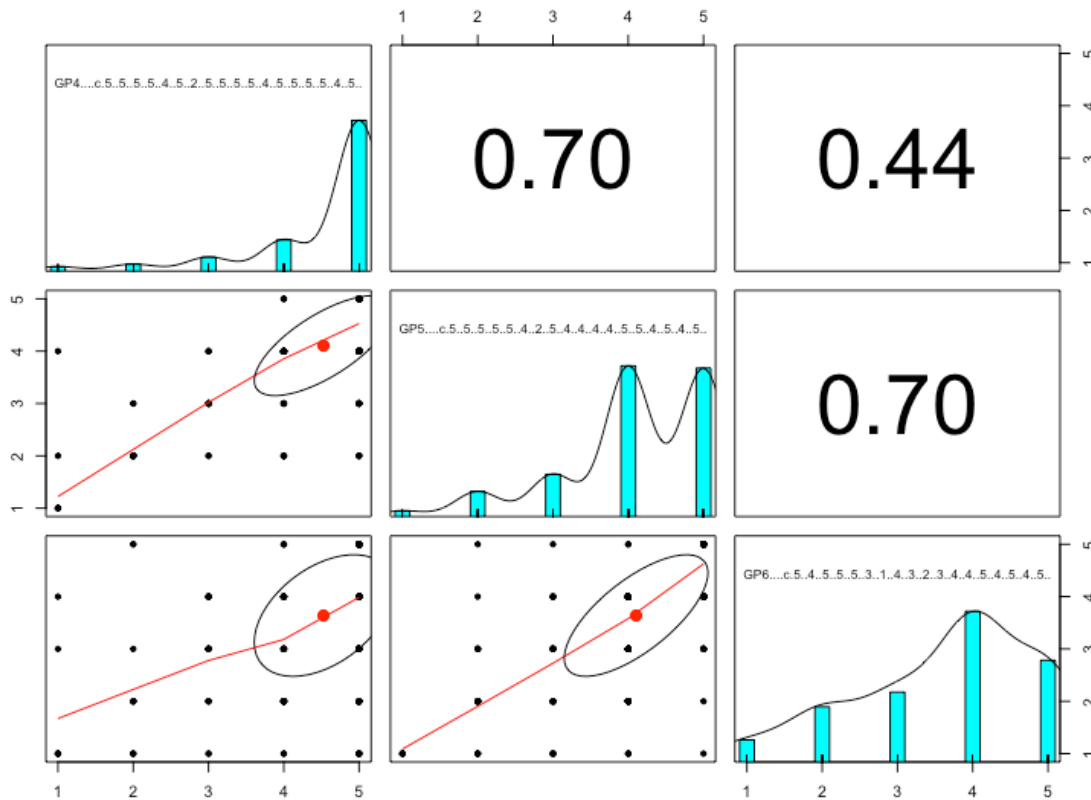
*Graph 16: Data from questionnaire, graph made by author*

The Spearman's rank correlation coefficient of perceived Covid-19 infection risk on walking and biking is [0.762512]. The Spearman's rank correlation coefficient of perceived Covid-19 infection risk on walking and vehicle is [0.5490315]. The Spearman's rank correlation coefficient of perceived Covid-19 infection risk on biking and vehicle is [0.5941839]. From this result, vehicle variable could be keep in the model, but biking and walking method has a high correlation. I also ran the Pearson correlation coefficient and the result was shown in the below Graph 17, walking and biking has a high correlation value of 0.76. Therefore, we should only choose one to represent them.



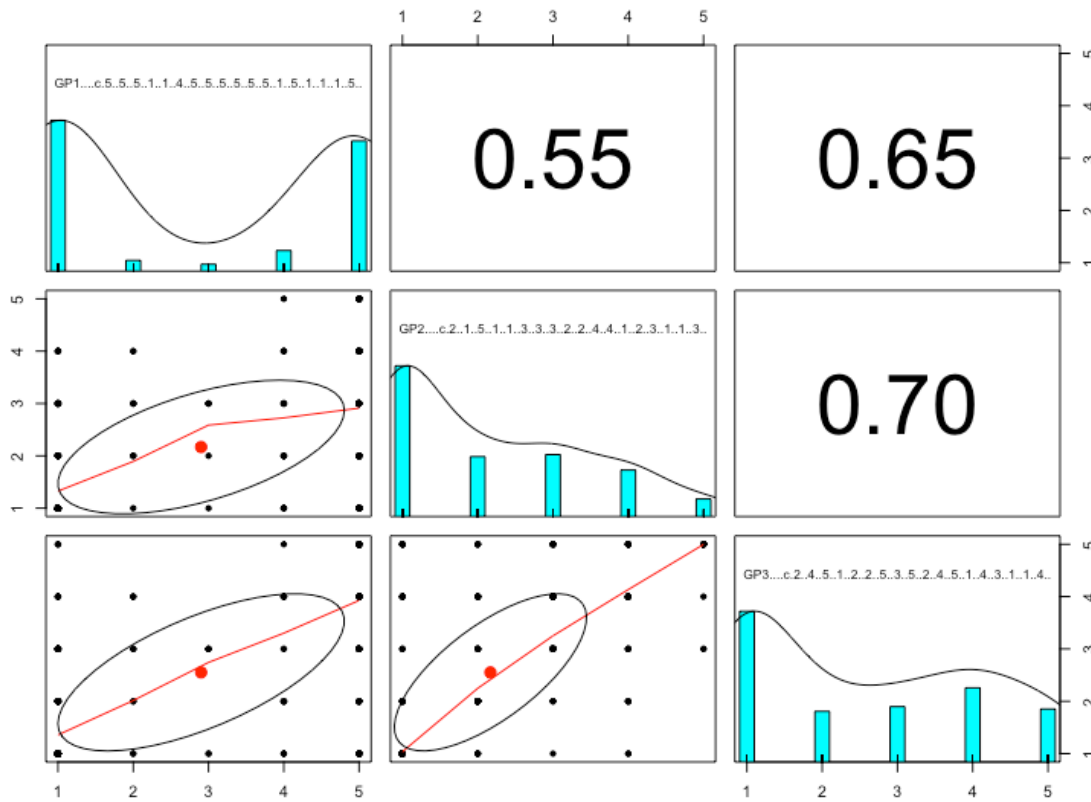
*Graph 17: Data from questionnaire, graph made by author*

The Spearman's rank correlation coefficient of GP4 and GP5 is [0.6006161]. The Spearman's rank correlation coefficient of GP6 and GP5 is [0.7217338]. I also ran the Pearson correlation coefficient and the result was shown in the below Graph 18, GP4 and GP5 has a high correlation value of 0.70. GP5 and GP6 has a high correlation of 0.7. However, GP4 and GP6 has low correlation. Therefore, we will eliminate GP5 from the variables.



*Graph 18: Data from questionnaire, graph made by author*

The Spearman's rank correlation coefficient of GP1 and GP3 is [0.657626]. The Spearman's rank correlation coefficient of GP2 and GP3 is [0.7306129]. I also ran the Pearson correlation coefficient, and the result was shown in the below Graph 19, GP1 and GP2 has a low correlation of 0.55, GP1 and GP3 has a relatively high correlation of 0.64, and GP2 and GP3 has a high correlation value of 0.70. Therefore, we will keep GP1, GP2 and eliminate GP3 from the testing variables.



Graph 19: Data from questionnaire, graph made by author

If the correlation coefficient equals 0.6, that represents a moderate positive relationship between two variables. Therefore, I will select one representative variable for those who have a higher value than 0.6, and keep the two variables that are below 0.6. After clarifying the high correlation variables, we are left with: Gender, Age, Education, Occupation, Vehicle Ownership, PTP1, PTP2, PTP3, PTP4, PTP5, PTP6, Social Influence, GP1, GP2, GP4, GP6, RP1, RP2, RP3, RP4, RP5, Perceived risks on trains, perceived risks on walking, Perceived risks on Vehicle, and Perceived risks on shared-mobility.

There are 6 dependent variables of the changes in utilization frequencies of each transportation method, and the 3 dependent variables of frequency changes for travel purposes. To understand how these dependent variables were under the influence of the 23

independent variables, the author used a stepwise regression model to run the results to determine the key influencing factors of the frequency changes for each transportation method.

For the frequency changes of walking, the final model is: (formula = Walkchange ~ Employee + PTP1 + RP1 + RP5 + Walking). The residual standard error is 7.94 on 310 degrees of freedom. There are 10 observations deleted due to missingness. The Multiple R-squared is 0.04984. The Adjusted R-squared is 0.03452. F-statistic is 3.252 on 5 and 310 DF, and the p-value is 0.007061. As the Table 2 shows below, the key influencing factors for frequency changes in walking are Employee, PTP1, and RP5. Respondents whose occupation is employee tend to walk less than other occupations. Respondents who agree with PTP1 tend to walk less than those who disagree. Respondents who agree with RP5 tend to walk less than those who disagree.

Table 2. Walking Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	3.1663	2.6340	1.202	0.2302	
Employee	-2.3239	0.9498	-2.401	0.0169	**
PTP1	-0.8185	0.4717	-2.106	0.0360	**
RP5	-0.7243	0.4251	-2.528	0.0120	**

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of biking, the final model is: (formula = BikeChange ~ student + ParttimeEmployee + PTP4 + GP1 + GP4 + RP1 + Biking). The residual standard error is 4.493 on 295 degrees of freedom. The Multiple R-squared is 0.07387. The Adjusted R-squared is 0.05189. F-statistic is 3.361 on 7 and 295 DF, and the p-value is 0.001826. As the Table 3 shown below, the key influencing factors for frequency changes in biking are Student, Part-time Employee, GP1, GP4, and RP1. Those respondents who are students tend to bike more than other occupations. Those respondents who are part-time employee tend to bike less than other occupations. Those respondents who agree with GP1 tend to bike more than those who disagree. Those respondents who agree with GP4 tend to bike less than those who disagree. Those respondents who agree with RP1 tend to bike more than those who disagree.

Table 3. Biking Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	0.1237	1.8289	0.068	0.9461	
student	5.8357	2.6284	2.220	0.0272	**
ParttimeEmployee	-1.3375	0.7850	-1.704	0.0895	*
GP1	0.2367	0.1375	1.721	0.0863	*
GP4	-0.6685	0.2980	-2.243	0.0256	**
RP1	0.4653	0.2728	1.706	0.0891	*

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of bus, the final model is: (formula = BusChange ~ Employee + GovernmentServant + PTP1 + RP4 + Bus). The residual standard error is 2.818 on 300 degrees of freedom. The Multiple R-squared is 0.07051. The Adjusted R-squared is 0.05502. F-statistic is 4.552 on 5 and 300 DF, and the p-value is 0.0005134. As the Table 4 shown below, the key influencing factors for frequency changes of buses are Employee, GovernmentServant, PTP1, and RP4. Those respondents who are employees tend to use buses more than other occupations. Those respondents who are Government servants tend to use buses less than other occupations. Those respondents who agree with PTP1 tend to use buses less than those who disagree. Those respondents who agree with RP4 tend to use buses less than those who disagree.

Table 4. Bus Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	1.6163	0.8038	2.011	0.0452	**
Employee	0.5955	0.3531	1.687	0.0927	*
GovernmentServant	-1.8795	0.7680	-2.447	0.0150	**
PTP1	-0.2394	0.1284	-1.865	0.0631	*
RP4	-0.2821	0.1706	-1.654	0.0992	*

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of Train, the final model is: (formula = TrainChange ~

Gender + Age + Education + Employee + GovernmentServant + SelfEmployed + PTP2 + GP4 + GP6 + RP2 + Train). The residual standard error is 6.751 on 288 degrees of freedom. The Multiple R-squared is 0.1655. The Adjusted R-squared is 0.1336. F-statistic is 5.191 on 11 and 288 DF, and the p-value is 1.88e-07. As the Table 5 is shown below, the key influencing factors for frequency changes of Train are: Age, Education, Employee, GovernmentServant, SelfEmployed, GP4, GP6, RP2, and Train. Those respondents who are male tend to use the train more than female respondents. Those respondents who have an education background lower than average tend to use more trains. Those respondents who are employees tend to use fewer trains compare with other occupations. Those respondents who are government servants tend to use fewer trains compare with other occupations. Those respondents who are self-employed tend to use fewer trains compare with other occupations. Those respondents who agree with GP4 tend to use less trains. Those respondents who agree with GP6 tend to use more trains. Those respondents who agree with RP2 tend to use fewer trains. Those respondents who agree with train has a high Covid-19 infection risk tend to use fewer trains than those who disagree.

Table 5. Train Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	15.42790	4.60239	3.352	0.000909	***
Age	-0.09084	0.04247	-2.139	0.033261	**
Education	-0.57434	0.18694	-3.072	0.002326	***
Employee	-4.34760	1.04045	-4.179	3.89e-05	***
GovernmentServant	-5.09457	2.18498	-2.332	0.020410	**
SelfEmployed	-4.64380	1.61110	-2.882	0.004244	***
GP4	-1.27347	0.3528	1.721	0.086360	***
GP6	1.21563	0.39667	3.065	0.002386	***
RP2	-0.76826	0.42102	-1.825	0.069077	*
Train	-0.80349	0.44023	-1.825	0.069011	*

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of Shared mobility, the final model is: (formula = SharedChange ~ Bike + PTP2 + PTP3 + PTP5 + PTP6 + GP6 + RP2 + RP3). The residual standard error is 1.486 on 295 degrees of freedom. The Multiple R-squared is 0.1051. The Adjusted R-squared is 0.08079. F-statistic is 4.329 on 8 and 295 DF, and the p-value is 5.973e-05. As the Table 6 shown below, the key influencing factors for frequency changes of Shared-mobility are: PTP3, PTP6, and RP3. Those respondents who agree with PTP3 tend to use less shared mobility than those who disagree. Those respondents who agree with PTP6 tend to use less shared mobility than those who disagree. Those respondents who agree with

RP3 tend to use less shared mobility than those who disagree.

Table 6. Shared Mobility Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept )	2.49930	0.62558	3.995	8.17e-05	***
PTP3	-0.22637	0.10325	-2.192	0.02913	**
PTP6	-0.19654	0.08973	-2.190	0.02929	**
RP3	-0.22161	0.08528	-2.599	0.00983	***

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of vehicle, the final model is: (formula = VehicleChange ~ Education + GovernmentServant + Bike + GP4 + RP1). The residual standard error is 5.604 on 296 degrees of freedom. The Multiple R-squared is 0.06001. The Adjusted R-squared is 0.04413. F-statistic is 3.779 on 5 and 296 DF, and the p-value is 0.002475. As the Table 7 shown below, the key influencing factors for frequency changes of vehicles are: GovernmentServant, Bike, GP4, and RP1. Those respondents who are government servants tend to use vehicles more than other occupations. Those respondents who have bikes tend to use vehicles more than those without a bike. Those respondents who agree with GP4 tend to use less vehicle than those who disagree. Those respondents who agree with RP1 tend to use vehicles more than those who disagree.

Table 7. Vehicle Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	-4.4186	2.7344	-1.616	0.10718	
GovernmentServant	2.8733	1.5165	1.895	0.05911	*
Bike	-1.3774	0.6482	-2.125	0.03443	**
GP4	-0.7494	0.3763	-1.991	0.04735	**
RP1	1.0384	0.3404	3.051	0.00249	***

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of going outside for non-work/study-related purposes, the final model is: (formula =NonWorkStudyChange ~ Gender + Employee + Bike + CleanEnergyVehicle + GP4 + RP5). The residual standard error is 4.502 on 298 degrees of freedom. The Multiple R-squared is 0.08941. The Adjusted R-squared is 0.07108. F-statistic is 4.877 on 6 and 298 DF, and the p-value is 9.01e-05. As the Table 8 shown below, the key influencing factors for frequency changes of going outside for non-work/study-related purposes are: Gender, Employee, Clean Energy Vehicle, GP4, and RP5. Those respondents who are male tend to go outside for non-work/study-related purposes more frequently than female respondents. Those respondents who are employees tend to go outside for non-work/study-related purposes more frequently than other occupations. Those respondents who have a clean energy vehicle tend to go outside for non-work/study-related purposes more

frequently than those who do not have a clean energy vehicle. Those respondents who agree with GP4 tend to go outside for non-work/study-related purposes less frequently than those who disagree. Those respondents who agree with RP5 tend to go outside for non-work/study-related purposes more frequently than those who disagree.

Table 8. Non-Work/Study Related Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	-1.8339	1.5379	-1.192	0.23403	
Gender	-0.5620	0.2733	-2.056	0.04061	**
Employee	1.3011	0.5587	2.329	0.02054	**
CleanEnergyVehicle	2.2092	1.1657	1.895	0.05903	*
GP4	-0.7289	0.2790	-2.613	0.00944	***
RP5	0.4716	0.2548	1.851	0.06520	*

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of going outside for work/study-related purposes, the final model is: formula = WorkStudyChange ~ Employee + SelfEmployed + PTP4 + PTP5 + GP4 + GP6 + RP1 + RP2 + RP4). The residual standard error is 7.213 on 294 degrees of freedom. The Multiple R-squared is 0.1586. The Adjusted R-squared is 0.1328. F-statistic is 6.157 on 9 and 294 DF, and the p-value is 5.968e-08. As the Table 9 is shown below, the key influencing factors for frequency changes of going outside for work/study-related purposes

are: Employee, Self-employed, RP2, and RP4. Those respondents who are male tend to go outside for work/study-related purposes more than female respondents. Those respondents who are employees tend to go outside for work/study-related purposes less than in other occupations. Those respondents who are self-employed tend to go outside for work/study-related purposes less than other occupations. Those respondents who agree with RP2 tend to go outside for work/study-related purposes less than those who disagree. Those respondents who agree with RP4 tend to go outside for work/study-related purposes more than those who disagree.

Table 9. Work/Study Related Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	2.9356	3.2088	0.915	0.36101	
Employee	-4.9483	0.9199	-5.379	1.53e-07	***
SelfEmployed	-5.0243	1.7104	-2.937	0.00357	***
GP4	-1.2956	0.5071	-2.555	0.01112	**
GP6	0.9637	0.4163	2.315	0.02130	**
RP2	-0.7704	0.4471	-1.723	0.08594	*
RP4	0.8725	0.4632	1.884	0.06060	*

(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)

For the frequency changes of going outside of Kashiwa city, the final model is: (formula = OutsideKashiwaChange ~ Age + Education + student + Employee + SelfEmployed + PTP5 + GP4). The residual standard error is 6.1 on 297 degrees of freedom.

The Multiple R-squared is 0.136. The Adjusted R-squared is 0.1127. F-statistic is 5.843 on 8 and 297 DF, and the p-value is 6.087e-07. As the Table 10 shown below, the key influencing factors for frequency changes of going outside of Kashiwa city are: Education, Employee, Self-Employed, PTP5, and GP4. Those respondents who have an education level lower than the average tend to go outside of Kashiwa city more frequently. Those respondents who are employees tend to go outside of Kashiwa city less frequently than in other occupations. Those respondents who are self-employed tend to go outside of Kashiwa city less frequently than in other occupations. Those respondents who agree with PTP5 tend to go outside of Kashiwa city less frequently than those who disagree. Those respondents who agree with GP4 tend to go outside of Kashiwa city less frequently than those who disagree.

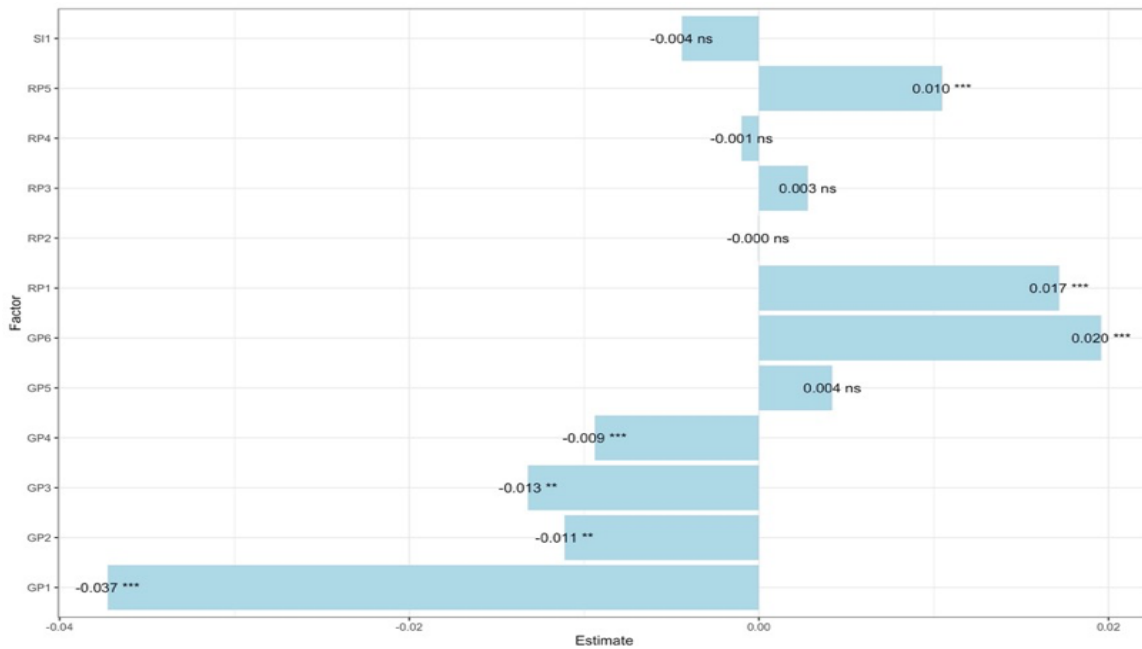
Table 10. Outside of Kashiwa City Frequency Changes

	Estimate	Standard Error	T-value	P-value	Signif. codes
(Intercept)	12.93332	3.57570	3.617	0.000350	***
Education	-0.32029	0.15561	-2.058	0.040435	**
Employee	-3.13611	0.86076	-3.643	0.000317	***
SelfEmployed	-3.65913	1.44124	-2.539	0.011631	**
PTP5	-0.76647	0.31838	-2.407	0.016675	**
GP4	-1.59506	0.44133	-3.614	0.000354	***

*(Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1)*

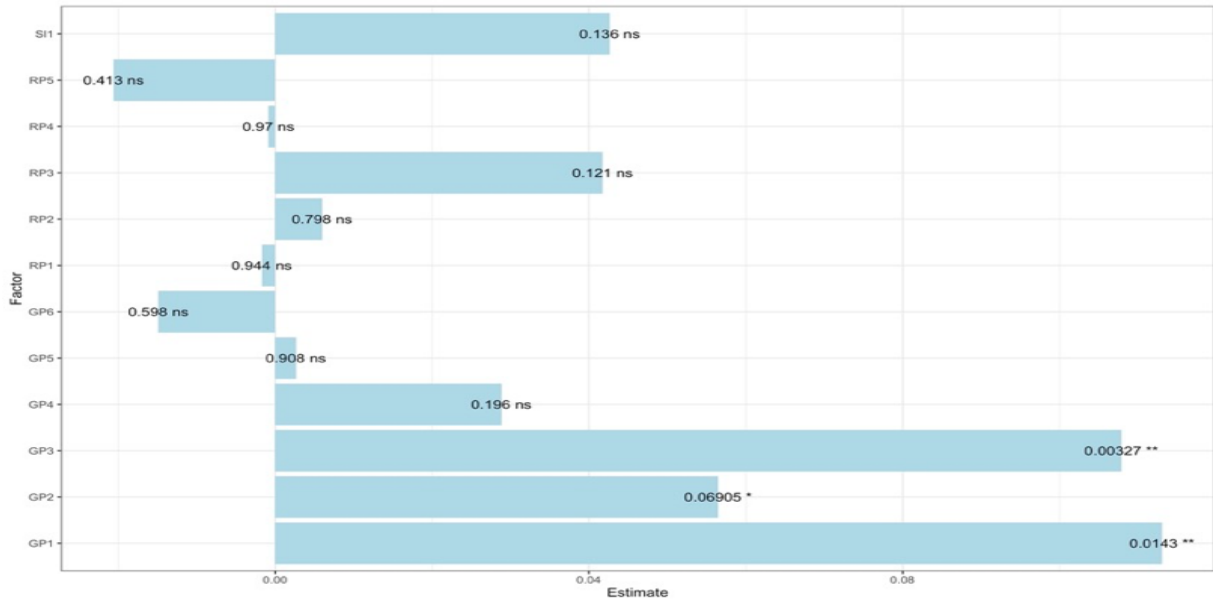
The author also tested the how much does socio-demographic features influenced individuals' choices. For example, the below Graph 20 represents which independent variable

has “age” play a significant role. Those respondents who aged higher than the average tend to agree with the RP5, RP1, and GP6 compare with those who aged lower than the average. Also, those respondents who aged higher than the average tend to disagree with the GP4, GP3, GP2, and GP1 compare with those who aged lower than the average.



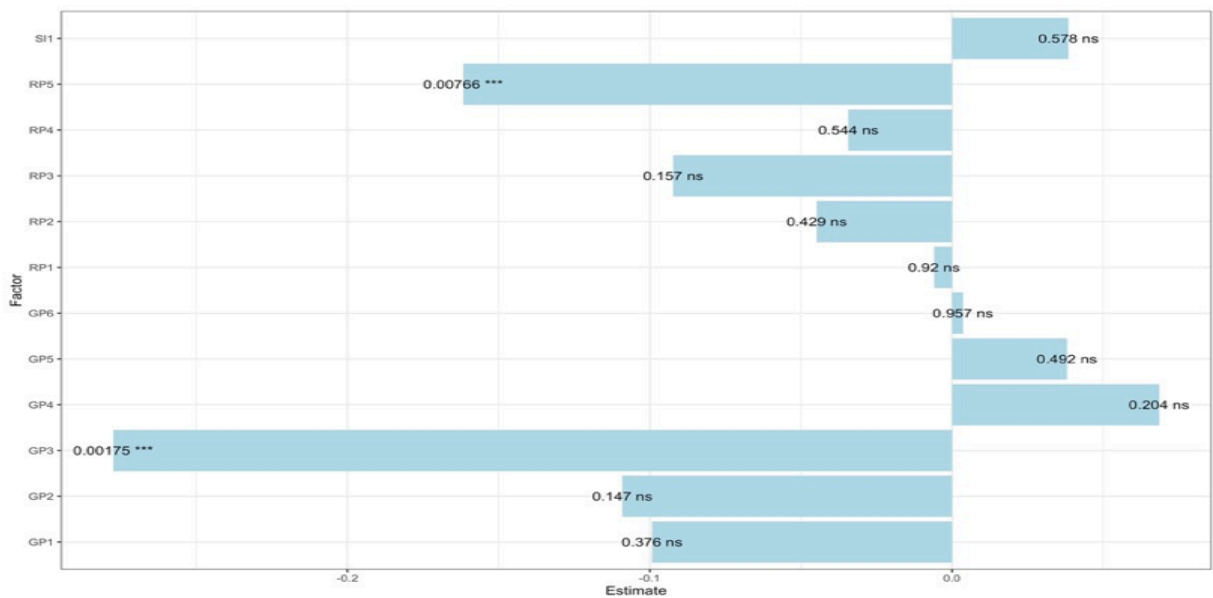
*Graph 20: Data from questionnaire, graph made by author*

The below Graph 21 represents which independent variable has “education” play a significant role. Those respondents who have a higher education than the average tend to agree with GP1, GP2, and GP3 more compare with those who have a lower education than average.



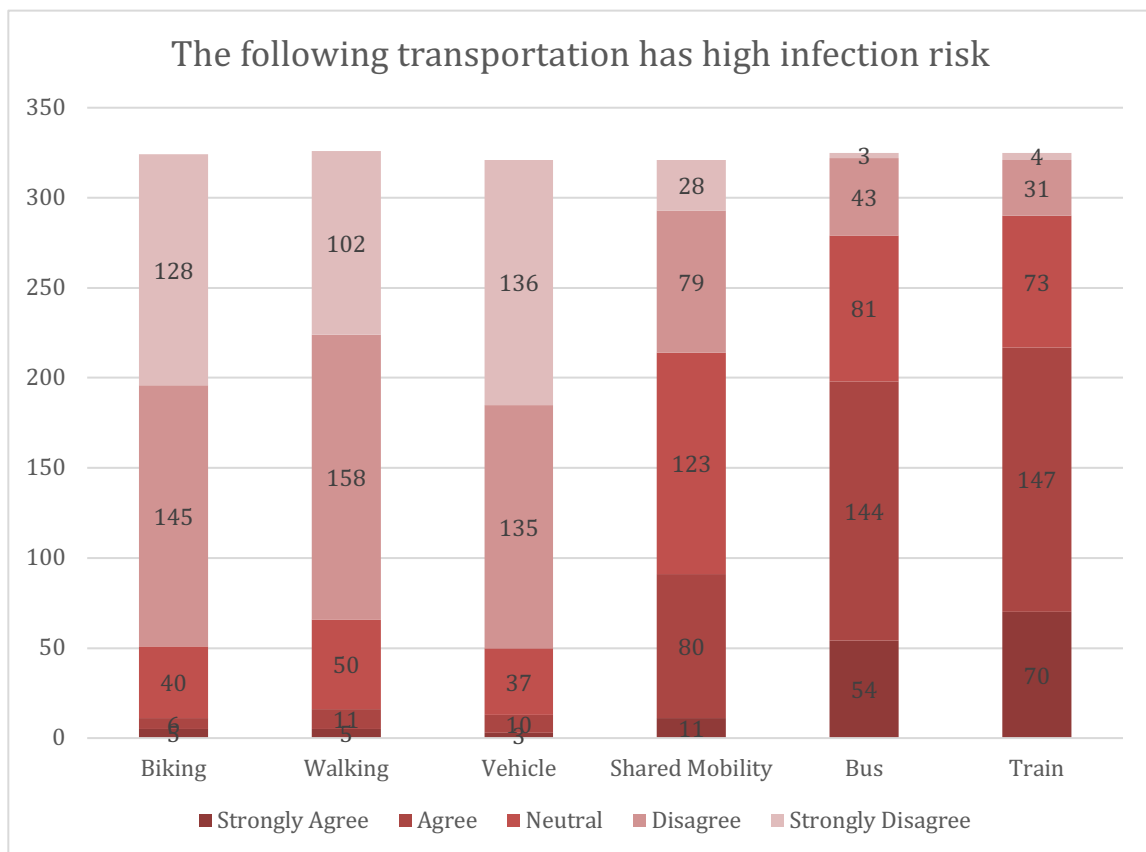
*Graph 21: Data from questionnaire, graph made by author*

The below Graph 22 represents which independent variable has “Gender” play a significant role. Those male respondents tend to agree more with RP5, and GP3 than female respondents.



*Graph 22: Data from questionnaire, graph made by author*

In term of the perceived Covid-19 infection risk of each transportation method, the visualization of results was shown in the below Graph 23. Biking apparently to be perceived as the transportation method with lowest Covid-19 infection risk, followed by walking, vehicle, shared mobility, bus and train. This result has one difference from the interview result, that is the change of order for vehicle and shared mobility. However, for both interviewees and respondents for the questionnaire, the percentage of people utilized shared mobility is low. There was only 12 out of 327 respondents had the experience to use shared mobility before.



*Graph 23: Data from questionnaire, graph made by author*

## **CHAPTER V: Discussion**

### **(1) Discussion**

In terms of prioritization in choosing certain transportation methods, the preferences of individuals differed based on their socio-demographic characteristics. For example, older people prioritize more about the infection risk of Covid-19 and the crowdedness during the transportation. Younger people prioritize more about the cost, time, distance, and transfer times during the transportation.

In term of the different governmental policies did cause different effects correspondingly. The State of Emergency Declaration, especially the first one lowered individuals' incentive to go outside. However, according to the questionnaire result, there was only a significant decrease in the use of trains during the State of Emergency Declaration. Based on the comments from the questionnaire, some respondents who are aged 60 and above, continue their previous travel behavior pattern, mainly due to their commuting needs for going to hospital. Consider the fact that 53% of my respondents in the questionnaire are people who aged 60 and above, it is possible that the older people's travel behavior is different than the younger generation during the pandemic. Another different is that older people feel constant towards the different waves of State of Emergency Declarations, their answers toward the policy's impact on their going out frequency did not fluctuate too much like the younger generations. For the Go-to Campaign policies, the older respondents are, the less likely they agree with such policy stimulate their incentives to go out. There is also a relatively negative attitude towards such policy from the older people, who complains and accused the Japanese government for wasting tax money for such policy.

In term of biking frequency changes explanation, students will bike more than other occupations, and part time employee will bike less than other occupations. People who often use Go-to Campaign will bike more often than others, as their general needs of going outside is higher than those who do not often use Go-to Campaign. People who agreed that the first State of Emergency Declaration lowered their incentives to go outside, will bike less, since their general commuting frequency goes down, and including bike, all other transportation methods also decreased utilization rate. People who prioritize the infection risk when choosing a transportation will bike more, is likely because they perceive biking as a low infection risk transportation method.

The risk level of each sustainable transport method is perceived by individuals appeared to be quite different. In term of walking, respondents whose occupation is employee tend to walk less than other occupations. The reason could be because most of the employees will utilize other transportation to commute to their companies. Those respondents who agreed with prioritizing the Covid-19 infection risk (PTP1) when choosing a transportation, will walk less. Also, for those people agreed that they are easily to be affected by Covid, will walk less than those who disagree. The reason is not because walking was perceived as a high infection risk transportation method, because only 16 out of 326 people agreed that walking has high infection risk. Therefore, the possible reason triggered this could be because most of the respondents who agreed with PTP1 are older people, and older people walk less in general.

The changes for transportation behavior occurred during the pandemic, has a potential to last for post-pandemic periods as well. For example, many respondents agreed that they will walk and bike more after the Covid-19 pandemic. For changes other than transportation

behavior, multiple people agreed that they will continue doing disinfection even after the pandemic. There are also other possible outcomes in post-pandemic, the purchases of vehicles and bicycles will last a longer effect on their travel behavior changes. The population with increasing utilization of biking and walking may continue even after the pandemic.

## **(2) Research Limitation**

The case study in Kashiwa city has several benefits, including the ability to conduct research from the viewpoint of a single city, the ability to serve as a model for other cities that commute to Tokyo, and the ability to shed light on how an aging city responded to the pandemic in terms of its transportation system and goals. The case study in Kashiwa city has several benefits, including the ability to conduct research from the viewpoint of a single city, the ability to serve as a model for other cities that commute to Tokyo, and the ability to shed light on how an aging city responded to the pandemic in terms of its transportation system and goals. The restrictions, however, should not be disregarded either. The research findings from this work may be difficult to replicate on a national scale, in other cities with different features, or in the situation of a city that is not considered as an aging city.

Another limitation is the distribution time of the questionnaire. The questionnaire asked questions about individuals' travel behavior before the pandemic and during the State of Emergency Declarations. However, the questionnaire was distributed at the end of April in the year of 2022. Therefore, it's possible that the respondents took a little longer to contemplate their responses, which might mean that they weren't viewed as timely. Additionally, because some of the interviewees' responses seemed to have different attitudes toward the first State of Emergency Declaration from the others, it's possible that the

questionnaire respondents will find it challenging to choose the response that best sums up their behaviors during all of the State of Emergency Declarations.

## **CHAPTER VI: Conclusion**

Overall, to answer the questions in the problem statement. Individuals' perceived risk on each transportation does not necessarily match their actual choices in transportation selection. For example, there are 33.3% respondents believed that shared mobility has a low infection risk. However, the actual usage of share mobility is only 3.68%. The reason is mainly since respondents rarely had the experience of using shared mobility, and their risk perception is based on their assumptions without facts. The key factors deciding individuals' risk perceptions are how well the disinfection was done, the frequency of air circulation, the crowdedness level, and the amount of people commuting to Tokyo, where was considered as a city with higher Covid-19 infection risk.

During the post-pandemic, there are numerous respondents replied that they will continue utilizing transportation methods that are good for their well-beings and physical strength. For example, biking and walking. However, although it is a positive sign for individuals to switch towards higher utilization rate of sustainable transportation methods, the reasons for them to think so, is primary due to the fact that Covid-19 alerted their concerns towards their health, rather than for environmental reasons. Other pandemic-related habits, such as disinfection or developing new interests, tend to carry over into the post-pandemic period as well. Regarding lifestyle, some respondents indicated that they had become aware of their capacity for remote work and that they would like to do more of it in the future.

As a summary of the perceived Covid-19 infection risk, Biking was rated as the mode

of transportation with the lowest chance of contracting the Covid-19 infection, followed by walking, driving, using a shared vehicle, taking the bus, and taking the train. The reason that biking was considered as a safer method than walking, is mainly due to the chances of talking to other people are lower. The possible countermeasures to encourage citizens using the perceived higher Covid-19 infection risk transportation would be, ensure proper disinfection, constant air circulation, control the number of passengers, and make sure there are no potential virus carrying passengers on the bus and train. For example, have an auto temperature check gate at the entrance.

Future policy recommendations should consider the main influencing main influencing factors for each transportation, in order to foster a more sustainable transportation-friendly society. Also, the comparison between a smart city Kashiwanoha, and the rest non-smart city regions, the biggest difference would be the response rate. Smart city residents have a significant higher response rate than other regions. However, other factors could not be determined as a significant difference. The smart city residents have no significant knowledge towards sustainable transportation methods, and the local government should promote such concept to create a more sustainable transportation friendly environment. In addition, the biggest different between a city scale and the capital city or national scale, is that the lower acceptance towards policies such as Go-To Campaigns. There are many respondents aged 60 and above in Kashiwa city, and they held a strong opposing opinion towards such policies. It is necessary for the local government to consider the will of older people in an aging city like Kashiwa city.

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## Appendix 1. Questionnaire

### アンケート

#### A. 回答者について

- 1) 性別： 女性 男性 回答しない
- 2) 年齢： 20歳未満 20代 30代 40代 50代 60代及び以上
- 3) 職業： 会社員 公務員 自営業 パートアルバイト 学生 無職
- 4) 最終学歴： 中学校 高等学校 短期大学 四年制大学 大学院卒以上
- 5) 郵便番号： \_\_\_\_\_
- 6) 所有しているもの： 自転車 クリーンエネルギー車 ガソリン/ディーゼル車

#### B. 交通手段の選択理由

5=そう思う;4=ややそう思う;3=どちらとも言えない;2=あまりそう思わない;1=まったくそう思わない

	5	4	3	2	1
7) 交通手段を選ぶ際に、コロナに感染する可能性を優先する					
8) 交通手段を選ぶ際に、コストを優先する					
9) 交通手段を選ぶ際に、掛かる時間を優先する					
10) 交通手段を選ぶ際に、距離を優先する					
11) 交通手段を選ぶ際に、乗り換え数を優先する					
12) 交通手段を選ぶ際に、混雑状況を優先する					

#### C. 政策の影響

5=そう思う;4=ややそう思う;3=どちらとも言えない;2=あまりそう思わない;1=まったくそう思わない

	5	4	3	2	1
13) 「Go To イート」または「Go To トラベル」キャンペーンを使ったことがある					
14) 「Go To イート」キャンペーンで外出の意欲を高めた					
15) 「Go To トラベル」キャンペーンで外出の意欲を高めた					
16) 1回目の緊急事態宣言で外出を控えた					
17) 2回目及び以降の緊急事態宣言で外出を控えた					
18) まん延防止で外出を控えた					

#### D. コロナのリスク認識

5=そう思う;4=ややそう思う;3=どちらとも言えない;2=あまりそう思わない;1=まったくそう思わない

	5	4	3	2	1
19) 私はコロナに感染することを恐れている					
20) 周りの人のコロナに対する態度は私の行動に影響を与えた					
21) 私はコロナとの対策と戦い方は知らない					
22) 私はコロナ禍を乗り越えにくいと思う					
23) 私はコロナに感染しやすいと思う					
24) 私の住む場所でコロナの感染リスクは低いと思う					

## B. 交通手段のリスク認識

5=そう思う;4=ややそう思う;3=どちらとも言えない;2=あまりそう思わない;1=まったくそう思わない

	5	4	3	2	1
25) 歩行でコロナに感染する可能性は高い					
26) 自家用自転車でコロナに感染する可能性は高い					
27) 自家用自動車でコロナに感染する可能性は高い					
28) 共有モビリティ（シェアリングサイクル、カーシェアリング、レンタカー）でコロナに感染する可能性は高い					
29) バスでコロナに感染する可能性は高い					
30) 電車でコロナに感染する可能性は高い					

## F. 交通手段の変化

31) 歩行の頻度(交通手段として、歩くことのみを目的とした歩行)

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

32) 自転車の利用頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

33) 自動車の利用頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

34) 共有モビリティ(シェアリングサイクル、カーシェアリング（レンタカー含む）など)の利用頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

## 35) バスの利用頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

## 36) 電車の利用頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

## 37) 柏市以外の場所に行く頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

## 38) 仕事や勉強の目的で外出する頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

## 39) 仕事や勉強以外の目的で外出する頻度

	していない	月1～3 日	週1～2 日	週3～4 日	週5～6 日	毎日
コロナ禍前						
緊急事態宣言中						

ご協力いただきありがとうございました！

コメント：\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_