IMPACTS OF RIDE-HAILING SERVICE (RHS) ON TRANSPORTATION MODES AND COMMUTER TRAVEL BEHAVIORS IN THE EMERGENCE OF URBAN MASS RAPID TRANSIT (UMRT): A CASE STUDY IN HANOI, VIETNAM.

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Abstract: In Vietnam, Ride-Hailing Service (RHS), both car-based and motorcycle-based, has entered the transport market in the context of metro systems being developed, with the first line being put into use recently. It is necessary to study its effects on the metro system, which is still in the development stage, to effectively implement the government's strategy of eliminating motorbikes and replacing them with public transport in 2030. This study provides a review of the current transportation status in Hanoi urban's traffic and initials empirically investigate the impacts of both car-based and motorcycle-based Ride-Hailing Service on other transportation modes, especially with the new urban railway coming into operation at the end of 2021. Initial data analysis of an observational survey shows the possible complement effect on the metro system of motorcycle-based RHS is a first and last-mile option for users. Shortly, a questionnaire survey is scheduled to quantitatively analyze more comprehensively the effects of car-based versus motorcycle-based RHS on different types of public transport (bus, bus rapid transit (BRT), metro).

Key Words: *Ride-Hailing Services, Motorcycle-based, Metro system, public transport, Developing country*

1. INTRODUCTION

The transformation of the urban transportation market during the last decade has undoubtedly been strongly influenced by Ride-Hailing Services (RHS). RHS is a form of mobility-on-demand in which travelers, instead of driving their own vehicle, pay for service trips through a smartphone application [1]. RHS connects consumers to drivers for the purpose of providing transportation services based on short-term contracts. Uber was founded in the U.S. in 2009, paving the way for explosive growth for RHS as the first company to offer this service. As of 2016, RHS has expanded significantly and has become popular worldwide, with 171 countries available using different application platforms. Uber is the world's most popular Ride-Hailing app, leading the market with 107 out of 171 countries, or 62% of the available territories, followed by Careem (Dubai-based) and Grab (Singapore-based) [2]. RHS offers the same thing as traditional taxis but differs mainly in its fare structures, operating rules, and service booking platforms [3].

Since RHS has been around for a relatively long time, many researchers have tried to learn about this type of service through their studies. However, the majority of findings and contributions of existing articles and studies focus on U.S. cities, while other regions of the world also record substantial growth in ride-hailing use [4]. Southeast Asia (SEA), home to

developing countries with dynamic and open economies that are becoming increasingly diversified and service-oriented, has been at the forefront of worldwide phenomena of digital disruption in numerous fields, such as digital economy, e-commerce, and ride-hailing apps with the emergence of a series of unicorn startups. It is worth noting that the SEA region's cities have unique characteristics compared to any other region in the world; for example, the level of public transport development is mainly low, high population density and the ownership and dependence on private means of transport are significant, especially motorbikes. Differences in the environment and context of RHS service implementation can play an essential role in the development of ride-hailing demand and influence user behaviors, thereby influencing the development strategy of more advanced public transport systems, which makes SEA countries a case study worth investigating.

Within the above general context, this study aims to add empirical evidence about the impacts of RHS in developing countries using the case of Hanoi, Vietnam, one of the major developing cities in SEA. The research evaluates the influences of both motorcycle-based and car-based RHS on different public transportation systems (bus, bus rapid transit, and metro) and commuter travel behaviors. The main objective is to reveal the relationship and the potential of trip chaining between RHS and other modes of transport, especially public transport. In this paper, an observational survey is conducted, and its preliminary analysis results show that potential of RHS to become the "first and last-mile" connection for the Urban Mass Rapid Transit (UMRT), representing a complement relation. A questionnaire survey is planned in the near future to collect users' data for quantitative analysis, thereby demonstrating these effects with more certainty and clarity.

The remainder of this paper is organized as follows: in the following section, the unique local contexts of Hanoi's transportation market, as well as the current state of the scientific knowledge regarding RHS influences, are summarized. Next, Section 3 shows the research framework follow by the formulation of the hypotheses from the literature search and the methodology. Finally, Section 4 presents a case study in Hanoi, including an observation survey, a discussion of the preliminary analysis results, and the questionnaire survey as the study's next step.

2. LITERATURE REVIEW

(1) Local contexts of Vietnam's transportation market

Vietnam, as a typical country of the SEA region, has experienced high population growth and rapid urbanization in its major cities. According to the Vietnam Population and Housing Census [5], the populations in the capital city, Hanoi, were around 6.4 million in 2009 before growing to approximately 8.0 million in 2019, indicating annual population growth rates of 2.2%. Along with population growth is rising traffic demand. The number of new vehicles registered in Hanoi has been steadily increasing. According to data from the Traffic Police Department (Hanoi City Police), in 2020 [6], there are about 7.6 million vehicles of all kinds in the capital, which there 740,000 cars, 5.8 million motorbikes, 150,000 electric motorbikes, and more than 1 million electric bicycles, not to mention all kinds of foreign and temporary vehicles. The average growth rate for cars increased relatively high, equivalent to 12.9%/year; motorbikes increased by an average of 7.6%/year. Notably, such a high automobile growth rate also reflects the fact that Vietnam is also experiencing a period of income growth at the same time. A transition from motorcycles to cars in the city is also recognized in a recent study [7]. Amid these events, however, the speed with which transportation infrastructure is developed remains inadequate. The Sustainable Urban Transport Index (SUTI) report for Hanoi reflected that the city's road length was 1,723 km in 2011 and 2,052 km in 2016, denoting an annual growth of 3.5% [8]. This imbalance between population increases and transport infrastructure development has meant that traffic congestion continues to worsen and increase in severity.

These circumstances have driven the Vietnamese government to prioritize public transport development, thereby replacing and eliminating motorbikes from Hanoi by 2030. In the project "The comprehensive urban development program in Hanoi Capital City of the Socialist Republic of Vietnam" (HAIDEP), built in 2007 with the help of JICA, Japan, the traffic problem in Hanoi was predicted, and public transport solutions for the city were proposed with four urban railway lines and BRT network. Later in 2011, the Vietnamese government announced an urban railway network of eight metro lines for the city of Hanoi. The HAIDEP report [9] also found that the average travel speed in the city in 2005 was 26.0 kph, which is expected to be 35.2 kph if Transport Demand Management (TDM) is available or 22.0 kph (without TDM) in 2020. Note that the expected speed in 2020 is achievable only upon the implementation of committed transportation infrastructure projects and the UMRT system. Unfortunately, this implementation did not go as planned, so the actual average travel speed is probably lower than reported estimates (9.4 kph in case of no UMRT and TDM). In September 2022, only one urban railway line was put into operation in November 2021 in

Hanoi (line 2A Cat Linh - Ha Dong). The following near-complete railway line, Line 3 Nhon - Hanoi Station, which started construction in 2009, will only be able to partially put into operation with the elevated section by the end of 2022. The underground section has requested a delay of completion with the expected date of full operation of the route in 2027. The remaining metro lines are all in the process of project implementation, and construction work has not officially started. Only one BRT line was introduced in Hanoi in 2017, and its effectiveness continues to be debated in the city. In short, the development of transport in Hanoi, Vietnam, especially public transport, is far behind the proposed plans and directly affects the deployment of the following pre-set objectives.

In the aforementioned development context, an unexpected new element has recently been introduced into Vietnam's transportation system, which has not been taken into account in mentioned previous reports, is the RHS. In 2014, Uber and Grab entered the Vietnam transportation market as RHS suppliers with motorcycle and car-based taxis. In 2015, a lawsuit happened between Grab and Vinasun- a traditional taxi company. The final judgment was that Grab was at fault but had to pay minimal compensation, and no further regulation was given. Grab in Vietnam has grown explosively, with over 37.000 Grab Taxi in 2017, and the number of Grab motorcycle taxis is expected to be even more significant. In 2018, Uber withdrew their activities from Vietnam and sold its market share to Grab, which makes them the biggest RHS company in Vietnam. Lots of new RHS companies with local-based joined the market shortly. In 2020, Vietnam established legal regulations on transport vehicle business conditions, paving the way for ride-hailing app providers in Vietnam. However, there is no policy to control the development or manage the direction of Grab's activities toward the city's traffic development goals. Since then, controversies have arisen, with many people mentioning it is a paradox: developing public transport to limit motorbikes but wide opening for RHS (motorbike) taxis to expand. With the current growth rate of public transport, RHS, urban railways, and other public transport almost surely coexist in Vietnam in the future. As evidence, RHSs have been developed and deployed in many countries, regardless of the level of development in these nations' public transport systems. Therefore, studying specific trends regarding travelers' behaviors possibly explains the prevalence of RHSs and their role in transport systems. Such an exploration would also be a suggestion for enacting policies and regulations by the government of Vietnam.

(2) State of knowledge

Existing scientific contributions on RHS have explored the service influences in various aspects. As specified by Dias et al. [10], there are four major topics of discussion around RHS: disruption, travel demand, regulation, and automation. There are also three groups of stakeholders related to RHS and the transportation market defined, including demand-side (RHS users), supply-side (RHS companies and companies providing communications for connecting users and RHS providers), and public-sector stakeholders (transport planning agencies, transportation regulatory agencies, other related transportation operators, such as taxi companies and public transit agencies) [11]. With such a broad scope of research, this part of the literature review focuses on the studies on the effects of RHS on commuter travel behavior and transport mobility.

Recent studies on RHS adoption in the U.S. and some regions have revealed several notable findings. Almost every study on the relationship between RHS and traditional taxi services has confirmed the substitution effect between them (e.g., [12],[13],[14],[15]). However, contradictory results are reported regarding the impact of RHS on public transit. Two authors from Brazil, Silva et al. [16] and Haddad et al. [17], reported the same trend of RHS taking away passengers from public transit. This trend is generalized across many studies about RHS in U.S. cities (e.g.,[18],[19],[20]). Noticeably, Hall et al. [21] stated that Uber increases public transport use for the average transit agency, which represents opposite effects to other studies, and this effect grows over time. Furthermore, another researcher in the US, Sadowsky et al. [22], also indicated that Uber served as a complement to public transportation use. Moreover, when Lyft, the second company, entered, the joint presence of the two major RH companies transformed RHS from a public transportation complement to a public transportation substitute. This substitution effect is also stated to be strengthen overtime. Along these lines, some authors, such as Young and Farber [23] specified that RHS is clearly too minute and inconsequential to influence the ridership level of other more substantial modes of travel, such as public transit and cars. As can be seen, the results and comments on RHS impacts on public transit are mixed, which suggests these effects might be different from country to country and region to region based on the characteristics and status of the transportation market. A study also indicated that as RHS becomes a reality for most of the population, the overall characteristics of RHS users and their trip characteristics may significantly differ from the current observations [24].

Developed countries, such as the United States, where the traffic market is dominated by cars, are

very different from the SEA region because motorcycles occupy a unique position here. In this area, motorcycle-based RHS is implemented and preferred over car-based RHS due to cheaper travel costs and shorter travel time [3]. Even though RHS has appeared in the SEA region for a long time, the number of studies on it is still limited. Although the results on characteristics of RHS users have many similarities, the characteristics of RHS trips and customer behavioral intentions from these studies are quite diverse and somewhat difficult to synthesize [11]. There are also relatively few studies that examined the impact of RHS on travelers' transportation mode substitution and complementarity in SEA. Contrasting results are also reported here. For example, a research paper on motorcycle-based RHS in Jakarta, Indonesia, stated that RHS is a substitution for public transport [25]. On the contrary, Irawan et al. [26] found that motorcycle RHS complemented conventional public transport as they served mainly access trips. It should be noted that these studies only consider car-based or motorcycle-based at once but not the combination of them. The same comment is also recognized as "a comparative analysis between different RHA modes, such as cars and motorcycles, is largely lacking" [11].

3. HYPOTHESES AND METHODOLOGY

(1) Hypotheses

This study develops hypotheses regarding RHS's expected impacts on its users' behaviors and transportation modes. It is reasonable to assume that all hypotheses should be based on the perspectives of local commuters because socioeconomic factors are anticipated to significantly impact mode selection [27]. We first postulate a hypothesis on the commuter's choice set observed in previous studies and then develop the remaining hypotheses on its basis. Figure 1 is illustrated this hypothesis formation step in our analytical process to methodically investigate the influence of RHS in the local context of Hanoi.

First, several researchers have noticed the potential of RHS as a paratransit mode in the transportation market. For example, Phun et al. [28] stated that the recent arrival of RHS might have altered the market for traditional paratransit services in developing Asian cities. Another study in Cambodia on the supply side also confirmed that RHS would be an opportunity for those paratransit drivers who adopt them, while it would be a threat for those who have not [29]. The same author has also noted that the concepts of

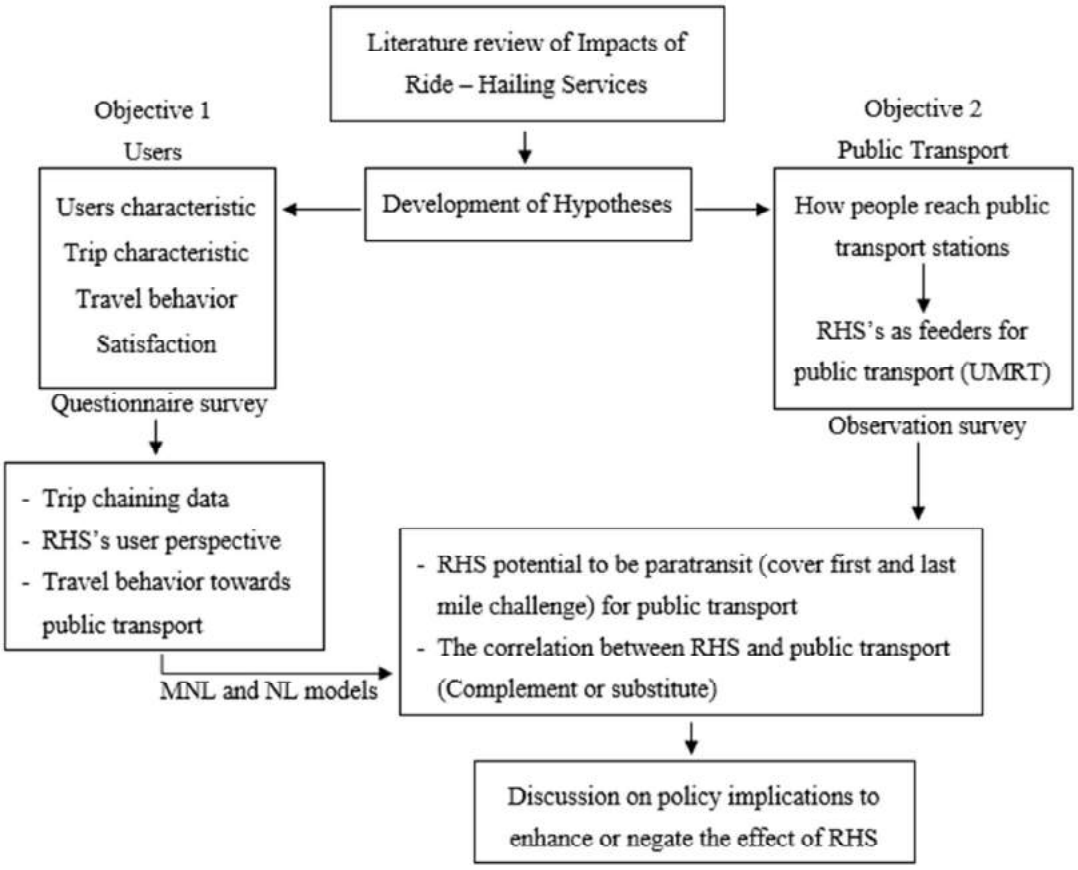

Figure 1. Methodological framework

paratransit are quite different between developed and developing countries. RHS is also verified to supply substantial trip services and complete the trips requiring no parking demand when exploring how RHS would affect travel patterns at peak hours [30]. Haddad et al.[17] also claimed in his study limitations as he could not identify the effect of RHS on multimode trips, limiting the capacity to evaluate the effects of RHS emergence on the first/last mile mode choice. This situation is more likely to happen in societies where RHS motorcycle-based is available, and a new type of advanced public transport (UMRT) has just been introduced. Therefore, the first hypothesis is formulated as follows.

> **H1.** RHS served as the first and last mile option for access trips to public transport, thereby denoted a complementary role.

Second, in the car RHS studies from Vietnam, transferring to other modes of transport was the trip purpose with the largest share at 40,6% [31]. This finding suggests the respondent's attitudes toward other transport modes, potentially public transport. It should be noted that the study was conducted in 2020, and Hanoi only put the first line of the metro system into operation in November 2021. Evidence suggests that more advanced forms of public transport will bring more benefits and thus attract more passengers. For example, Sadowsky et al. [22] suggested that RHS entry affected the behavior of bus riders differently than it did rail riders and the difference in usage response to ride-hailing entry is a topic worth exploring further for the cities that have both modes. Additionally, when comparing the standard bus with the BRT in Vietnam, Tung et al. [32] found that Hanoi BRT service had significantly positive impacts on improving travel time efficiency, increasing the acceptable walking distance to the nearest stop, and encouraging commuters to use more public transportation in their daily journeys. Such positive effects could be followed by the emergence of the metro system, which outperforms bus types in congested cities like Hanoi. With the combination of RHS, the travel distance to the station for metro use is expected to have less impact. Thus, our second and third hypotheses are as follows.

> **H2.** The more advanced the public transport mode (UMRT>Bus), the greater RHS's complementary impact on public transport will be.

> **H3.** The convenience of RHS combined with the emergence of UMRT is attractive enough to make commuters shift from private vehicles to public transport.

Third, the number of studies consider the influences of RHS using both car and motorcycle-based data, and the comparison between them is inadequate [11]. In 2022, Tung et al. [3] recently acknowledged some aspects of comparison between car and motorcycle-based RHS. Motorcycle RHS is declared to have a shorter travel time than car RHS. Additionally, traffic congestion affects the choice of car-based RHS alternatives, but not motorcycle-based RHS. Such declarations suggest motorcycle RHS is the better choice for the first and last-mile trip. Cheaper commuting cost when traveling by motorcycle RHS compared to car RHS is also a good motivation for such thinking. The fourth hypothesis is stated as follows.

> **H4.** The complementary effect on public transport of RHS motorcycle-based is much stronger than RHS car-based.

Finally, some studies in SEA pointed out the negative impacts of RHS as it substitutes trips from public transport. A study conducted on car-based RHS users in Manila concluded that RHS is a substitution for public transport and walking [33]. Another study in Jakarta also pointed out that RHS replaced both private vehicle trips and public transit [25]. It should be noted that those results might be explained by Manila and Jakarta's overcrowded and limited public transport system, which pushed commuters to switch to RHS [11]. Moreover, a study verified that motorcycle RHS, like conventional motorcycle taxis, served mainly short-distance trips [26]. We would like to confirm those comments in the context of the Hanoi transportation market. Accordingly, the fifth hypothesis is as follows.

> **H5.** The ability of RHS to serve as first and last-mile connections is affected by the level of development and completion of the public transport system and depends on the travel distance.

(2) Methodology

As the questionnaire survey is designed to generate a choice set of alternatives, Multinomial Logit Regression (MNL) and Nested logit regression (NL) are used to analyze the extracted data to investigate and identify traveler-related variables affect mode selections, then estimate the model's underlying coefficients. The MNL and NL model are commonly used in utility function techniques for modeling and identifying mode choices in travel behavior analysis. Models of mode selection statistically link each traveler's decision to the characteristics of the available alternatives. The MNL model treats all alternatives

equally, whereas the NL model includes intermediate branches that group alternatives [34].

The MNL model assumes that all the options in the choice set adhere to the independence from irrelevant options property. As a function of the systematic portion of the utility of all the alternatives, the MNL provides the choice probabilities for each alternative. The MNL describes how the independent variables are interconnected to the dependent variable and are expressed in terms of utility. The probability of selecting an alternative 'i' from a choice set of j alternatives is expressed using Equation (1):

$$\Pr(i) = \frac{\exp(V_{in})}{\sum_{i=1}^{j} \exp(V_{in})} \quad (1)$$

Where:

$\Pr(i)$ = is the probability of utility for a mode choice (n) by the traveler choosing alternative (i),

V_{in} = is the utility function for a mode choice (n) by the traveler choosing alternative (i),

V_j = is the systematic component of the utility of the set alternative (j).

The NL models rely on the idea of substitutional effects between the alternatives in the choice set. A nested logit model is applicable when the subsets of comparable options are grouped in nests. In this study, there are two possible ways to form mode choice groups: the "Public and private transportation modes" group or the "Motorcycle and car modes" group. As a generalization form of the MNL model, The NL model can be calibrated using standard logit estimation to find coefficients. The structure of the NL model is expressed using Equation (2):

$$P_{ji} = \frac{e^{\beta' S_{ji}}}{\sum_{i=1}^{j} e^{\beta' S_{ji}}} \quad (2)$$

Where:

P_{ji} = is the probability that alternative j chosen by traveler i,

β' = is a vector of all estimable coefficients for alternative j,

S_{ji} = is a vector of all explanatory variables for traveler i.

4. EMPIRICAL STUDY

(1) Case study in Hanoi.

Hanoi, the capital of the Socialist Republic of Vietnam, has a population of over 8.0 million residents in an area of 3359 km2. It is the second largest city in

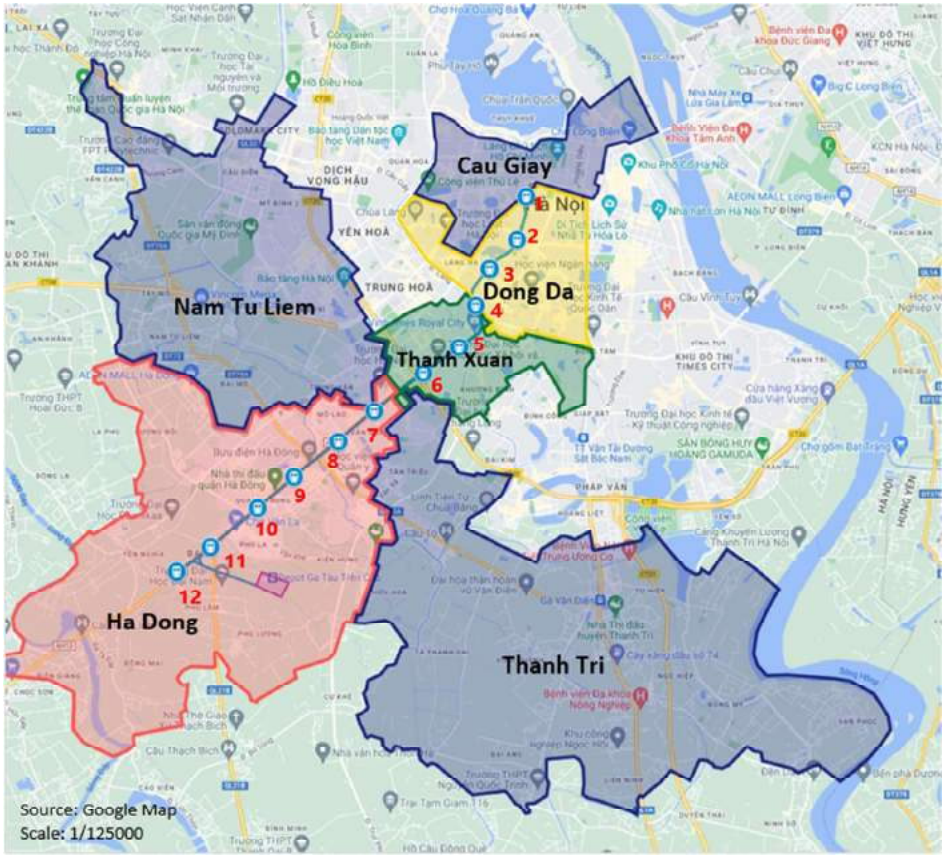

Figure 2. Case Study in Hanoi - Metro Line 2A

the country and the economic hub of North Vietnam. Under the current context of Hanoi transportation market shown in the literature view section, this study schedules an interview survey using a questionnaire sheet in the areas surrounding Metro Line 2A station. Figure 2 illustrates the location of Metro Line 2A and its points of interaction with the central districts of Hanoi. Hanoi Metro Line 2A has a length of 13,05 km, with twelve stations all above the ground. With a total investment of more than 758 million USD and over ten years of construction, Metro Line 2A was put into operation on November 6, 2021. It passes through three districts: Ha Dong, Thanh Xuan, and Dong Da, and it is capable of connecting traffic with three neighboring districts: Ba Dinh, Nam Tu Liem, and Thanh Tri. Five out of these six districts are the city CBDs. The ticket fare is 15000 VND for a complete trip between two ends – Cat Linh and Ha Dong station. The price is 30000 VND and 200000 VND for one day pass and monthly pass, respectively. In addition, there are also preferential fares for subjects such as students, workers in industrial zones, employees at offices, businesses outsides industrial zones, and monthly pass prices purchased in the collective form.

The questionnaire survey is scheduled to be conducted at surrounding points near the stations, such as supermarkets, markets, residential areas, office buildings, and universities. Stations No. 1,6,7 and 12 are selected as shown in Figure 2. Station 1 – Cat Linh station is near Kim Ma bus station and surrounded by companies, buildings, and hotels (Business zone). Station 6 is located near the city's residential areas and Ring Road 3. Station 7 is also located close to the residential areas with four universities nearby. Finally, around station 12 is an industrial zone and Yen Nghia bus station. It should be noted that Kim Ma and Yen Nghia are one of the biggest bus stations in Hanoi, which are also the BRT's starting and ending points. The questionnaire survey is already formed with the expected data illustrated in Appendix A and will soon be performed in a couple of months.

(2) Observational survey and discussion on the preliminary results.

An observational survey was conducted in August 2022 in the area near the four stations specified for the questionnaire survey. This observation aims to confirm the trend with academic research through literature review, identify unseen factors to add on and complete the questionnaire. Furthermore, it is also for preparing the location and specifying the rollout time for the upcoming survey. Cameras were installed in several locations around the designated stations to record. Depending on availability, the location was on the pedestrian bridge or opposite the sidewalk. The shooting time is approximately 30-minute periods in the morning, noon, and night. However, due to the designs of the station and the quality of the recording, only station No.1 in the morning and noon is suitable for the tally of images to acknowledge what mode commuter use to connect to the metro station. The preliminary result is shown in Figure 3.

As can be seen from the chart, the two time periods taken as representative of morning and noon are from 8:00 to 8:30 and 12:30 to 13:00, respectively. The number of people using motorcycle RHS to connect to the station ranks second after the walking commuter. Thus, it is reasonable to consider hypothesis 1 logical for further study. The number of people

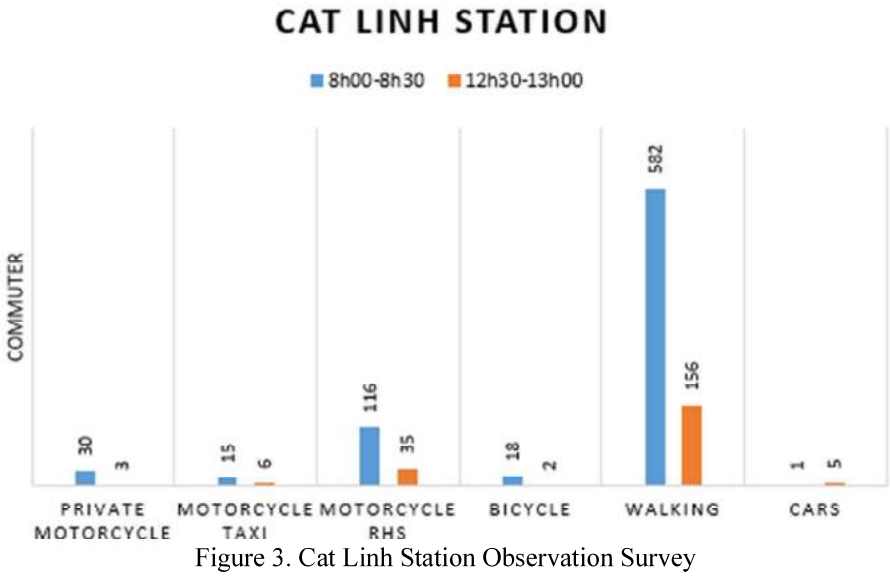

Figure 3. Cat Linh Station Observation Survey

observed in the morning is much higher than at noon, which is also rational. It reflects Vietnamese people's habit of having lunch at work and then resting or eating out but not going too far from work. Therefore, the time for conducting the questionnaire survey should be in the morning or afternoon (when people return home from work or hang out). Another thing that can be noticed is that very few people were observed to use cars to connect to the metro station.

This survey is intended to test the feasibility of the hypotheses. As expected, there are many difficulties making confirmation of hypotheses possible only through quantitative analysis using data from a questionnaire survey. For example, it is impossible to distinguish between walking commuters who walk only or who use other modes (e.g., buses) to connect to the metro station. Such measurement that could cover those problems and be capable of verifying all hypotheses that have been proposed will be carried out over the shortly and thereby complete this study.

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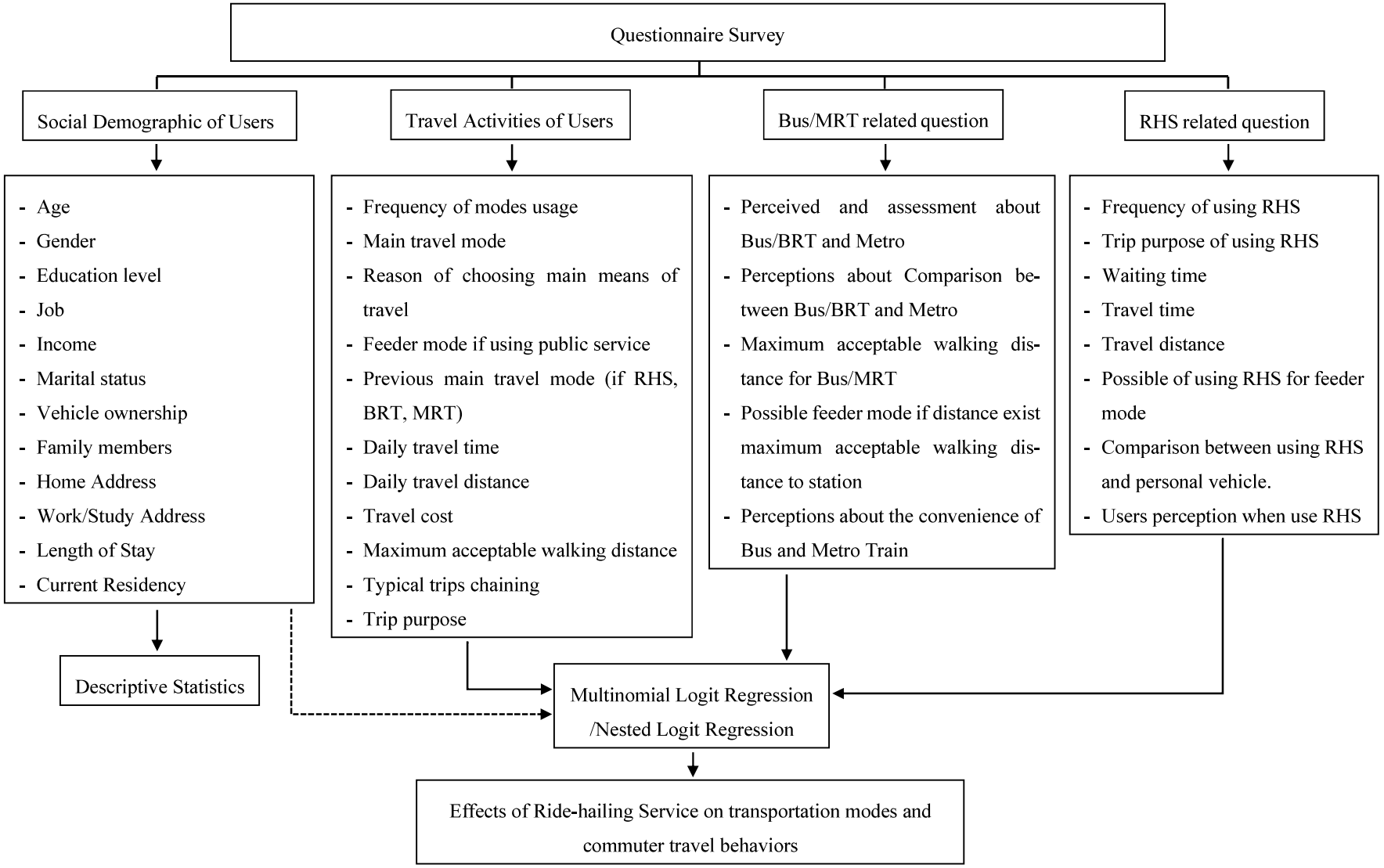
APPENDIX A


Questionnaire Survey
Social Demographic of Users
Travel Activities of Users
Bus/MRT related question
RHS related question
- Age
- Gender
- Education level
- Job
- Income
- Marital status
- Vehicle ownership
- Family members
- Home Address
- Work/Study Address
- Length of Stay
- Current Residency
- Frequency of modes usage
- Main travel mode
- Reason of choosing main means of travel
- Feeder mode if using public service
- Previous main travel mode (if RHS, BRT, MRT)
- Daily travel time
- Daily travel distance
- Travel cost
- Maximum acceptable walking distance
- Typical trips chaining
- Trip purpose
- Perceived and assessment about Bus/BRT and Metro
- Perceptions about Comparison between Bus/BRT and Metro
- Maximum acceptable walking distance for Bus/MRT
- Possible feeder mode if distance exist maximum acceptable walking distance to station
- Perceptions about the convenience of Bus and Metro Train
- Frequency of using RHS
- Trip purpose of using RHS
- Waiting time
- Travel time
- Travel distance
- Possible of using RHS for feeder mode
- Comparison between using RHS and personal vehicle.
- Users perception when use RHS
Descriptive Statistics
Multinomial Logit Regression /Nested Logit Regression
Effects of Ride-hailing Service on transportation modes and commuter travel behaviors