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Influence of the COVID-19 pandemic on old-style LAMAT services in developing cities of Asia: The case study of Phnom Penh

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ABSTRACT

Urban mobility is likely to undergo significant changes due to the ongoing COVID-19 pandemic and future potential outbreaks. This study examines the influence of the COVID-19 pandemic on the operational services of old-style LAMAT (i.e., Remork) drivers. The pandemic’s influence was investigated using several analytical approaches—including mean comparison and regression analyses—which used data collected from an interview survey with 186 Remork drivers in Phnom Penh from December 25–28, 2020. The results indicated a negative influence of the COVID-19 pandemic on the livelihoods of Remork drivers; that is, the drivers’ monthly income has substantially declined since the pandemic began (p < 0.01). The impacted drivers also expressed their difficulties during the pandemic and requested various forms of public support. This study provides different perspectives on analytical techniques to examine the possible influence of COVID-19 on society and offers guidance for relevant urban transport policies in response to the current pandemic and the new normal.

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1. Introduction

The outbreak of COVID-19 has significantly influenced people’s daily lives and travel behaviors. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a global pandemic. Since then, many governments have temporarily suspended all non-essential businesses and activities and have implemented preventive measures—including social distancing and lockdowns—to minimize the rapid transmission of the virus. One of the sectors that has experienced a major impact is the transport sector. Following the outbreak, mobility restrictions were proposed in many countries worldwide, including Cambodia. The mobility restrictions are directly associated with country border closures, public transport service suspension, and imposed curfews. Mobility has also been affected by the temporary closure of schools, offices, businesses, entertainment venues, government buildings, and private institutions. As a result, the level of general urban mobility decreased dramatically (Aloi et al., 2020; Koehl, 2020; Google, 2021; Gutiérrez et al., 2020).

Citizens’ choices about travel modes have been influenced by social distancing norms and the increased risks associated with crowded places. A remarkable change has been observed in the modal split, in which there is a decline in public transport share and replacement by private transport (Bhaduri et al., 2020; Buesky, 2020; Tan and Ma, 2021). This might also be the case for the demand for LAMAT services in developing cities of Asia. The term “LAMAT” is a new concept first proposed by Phun and Yai (2016). LAMAT is defined as “the indigenous public transport modes that are locally, adapted, modified, and advanced for a certain transport service in a particular city or region.” The term “LAMAT” has been proposed to replace the term “paratransit” in Asia because the concept of paratransit in developing countries is quite different from how it is viewed in developed countries. LAMAT includes “all intermediate public modes between the private transport and the mass transit system, ranging from non-motorized two-wheelers (bicycle taxis) up to motorized four-wheelers (minibuses), with a maximum seating capacity of about 25.” In several cities in Asia, where there is an insufficient mass transit system, LAMAT supports urban mobility considerably (Phun and Yai, 2016). LAMAT serves as personalized transport for many citizens and provides transport services that are adaptable and convenient with a reasonable fare. LAMAT also supports socio-economic activities through the availability of transportation services as well as job opportunities for low-skilled individuals. In spite of these benefits, governments often regard LAMAT services as informal transport services.
and, hence, tend to provide little support in the form of policy or infrastructure.

Studies have been conducted to explore the effects of the COVID-19 pandemic on the transport sector, and countermeasures have been examined by several researchers (e.g., Abdullah et al., 2020; Jenelius and Cebecauer, 2020; Sharifi and Khavarian-Garmsi, 2020; Zhang, 2020). Yet, there has been limited investigation of the impact of the pandemic on LAMAT services in the developing cities of Asia (Hasselwander et al., 2021; Sogbe, E., 2021). Hasselwander et al. (2021) conducted a macroscopic study, using aggregated cellphone and GPS data to investigate the influence of the COVID-19 pandemic on mobility behavior (e.g., jeepneys) in Metro Manila. They found that the people most reliant on public transport were disproportionately affected by lockdowns; public transport was unable to fulfill its role as a public service, and this drove a paradigm shift toward active mobility. Sogbe (2021) investigated the effects of the COVID-19 pandemic on public transport in Ghana, using online and paper-based questionnaires from the viewpoints of commuters. The author found that there was a sharp decline in the use of paratransit services with high occupancy, such as “TroTro,” in favor of the use of taxis. However, to the best of our knowledge, there is no literature that investigates the influence of the COVID-19 pandemic on LAMAT services, especially those old-style operators who have not adopted new technologies (i.e., ride-hailing apps), from the operator perspective.

This study examines the influence of the COVID-19 pandemic on the operational services of old-style LAMAT (i.e., Remork) drivers who continue to operate without a ride-hailing app (RHA). We examine the influence of the pandemic through various analytical approaches—including mean comparison tests and the regression method—using the survey data collected from 186 Remork drivers aged 23–72 in Phnom Penh as a study case. A Remork is a sort of auto-rickshaw, which is domestically assembled using a motorcycle and a carriage (i.e., a four-wheeled vehicle). This study targeted old-style Remork services because their popularity has gradually declined since the advent of RHAs (Phun et al., 2020) and has likely decreased further under COVID-19 circumstances. Due to this situation, Remork drivers tend to be one of the most affected groups of transport operators in Phnom Penh. The findings of this study serve to provide insight into policy discussions on how to manage and control the old-style LAMAT operations in the city, especially during the COVID-19 pandemic period and afterward.

2. COVID-19, urban mobility, and LAMAT services in Phnom Penh

2.1. COVID-19 situation and urban mobility

The Ministry of Health publicly announced the first confirmed case of COVID-19 on January 27, 2020. Fig. 1 shows the change in urban mobility in Phnom Penh and the number of confirmed COVID-19 cases in Cambodia from February 15, 2020, to March 9, 2021. It was found that the mobility trends in Phnom Penh have declined in places like retail and recreation venues (by 30%), parks (by 33%), workplaces (by 23%), grocery and pharmacy locations (by 20%), and transit stations (by 58%), compared to the baseline. The amount of travel to transit stations has been severely influenced by the COVID-19 pandemic because the government suspended public transport services (e.g., public bus, water taxi) beginning on March 26, 2020 (Baetzner et al., 2021). It is expected that public transport services will resume when the COVID-19 situation improves. Since overall urban mobility has declined during the pandemic, a decline in the demand for LAMAT services, including Remork services, is also expected. It should be noted that in Fig. 1, a series of abrupt declines in urban mobility were caused by two factors: national holidays and COVID-19 events, as follows: ① was the mid-April travel restrictions. At the early stage of the COVID-19 pandemic in Cambodia, the government postponed the Khmer New Year (April 14–16, 2020) from mid-April to August 2020 and imposed restrictions on travel between Phnom Penh and other provinces. All civil servants, workers, and employees were required to continue their work normally. The postponement of national holidays and travel restrictions were efforts to reduce the spread of the COVID-19 pandemic; ② and ③ were the resumed Khmer New Year period and New Year’s Eve 2021; ④ was the Cambodian religious festival, known as Pchum Ben; and ⑤, ⑥, and ⑦ were the COVID-19 community outbreak events.

2.2. LAMAT services

The current public transport modes in Phnom Penh include the public bus and LAMAT services (Phun et al., 2020). As of 2019, the public buses were operated on 13 routes in the city, using a fleet of around 200 buses (UNDP, 2021). The bus services were available with a fixed fare of 1500 KHR (approximately 0.75 USD as of March 2021),

![Fig. 1. Change in urban mobility in Phnom Penh and number of confirmed COVID-19 cases in Cambodia from February 15, 2020, to March 9, 2021 (Data source: Google, 2021; Mo, 2021).](image-url)
from 5:30 to 20:30 daily, with the headway from 5 min to 20 min, depending on the bus operating route and time of the day. Since the public bus services remain limited, they were not especially attractive; the buses averaged approximately 25,000 passengers per day, up to 60% of whom were identified as free riders. However, public bus services have been suspended since March 26, 2020, due to the advent of the COVID-19 pandemic. Given the limited or absent public bus services in Phnom Penh, citizens now mainly depend on LAMAT services to traverse the city. While the public bus provides a fixed-route transport service, the non-fixed routes of LAMAT provide more convenient transport services (i.e., flexible, door-to-door) to citizens with a reasonable fare.

LAMAT modes include auto-rickshaws, motorcycle taxis, and cyclos. Auto-rickshaws (up to six passengers) are more attractive than motorbike taxis (locally known as Motodop, for up to two passengers) because auto-rickshaws have a higher capacity, more comfort, and greater safety. Auto-rickshaws consist of Remorks and other motorized three-wheelers. A Remork is a two-wheeled carriage pulled by a motorcycle—thus, it is a four-wheeler. Remorks are domestically assembled without a specific safety standard. The government requires that Remorks meet minimum safety requirements, including an effective braking system, a light system, rearview mirrors, and a horn ≤ 99 dBA. The size of a Remork must be ≤ 3.5 m in length, in width ≤1.4 m, with a height of ≤ 2 m.

Since 2016, the number of motorized three-wheelers has been observed to increase in Phnom Penh. These three-wheelers were imported from other countries, including China and India. We collectively refer to motorized three-wheelers from India (e.g., Bajaj, TVS, Piaggio) as “Bajaj” and those from China as “Chinese auto-rickshaws.” The growing popularity of Bajaj services via RHAs has become the main reason for the number of daily trips, daily passengers, and monthly income have declined by 47.7%, 47.6%, and 43.2%, respectively (Phun et al., 2020).

In Cambodia, LAMAT services are regarded as informal, and there is thus no specific control over their operations. Drivers are not required to register in order to operate LAMAT, but they need to have their vehicles registered. Registration of auto-rickshaws began in 2009, and based on the Department of Public Works and Transport, there were 18,030 auto-rickshaws registered in Phnom Penh in February 2018. This number quickly increased to 29,288 in November 2018. Within the same period, the number of registered Bajaj drivers jumped from 3232 to 14, 338—while the number of registered Remorks (10,091) remained constant. This tendency suggests the increasing popularity of Bajaj services over other auto-rickshaws, especially Remorks. Without formal control over the operational services of Motodops (e.g., driver’s license requirements), anyone with a motorcycle could serve as a Motodop driver. As a result, the number of Motodops is still in question. A Cyclo (one to two passengers) is a three-wheeler powered by a human. The popularity of cyclos has been steadily declining. The Cyclo Conservation and Careers Association reported that the number of cyclos in Cambodia decreased from about 1500 in 2007 to around 700 in 2012. Currently, most cyclos are used for short-distance trips around markets and for tourism purposes.

3. Data

3.1. Interview survey

This study analyzed the sample data collected from a face-to-face interview survey with old-style Remork drivers in Phnom Penh, conducted December 25–28, 2020. The survey was based on a questionnaire in Khmer, which consisted of four parts. Part 1 asked Remork drivers about their overall transport services. Part 2 inquired about their operational services before and during the COVID-19 pandemic. Part 3 inquired about their subjective responses concerning RHAs. The subjective questions were developed based on a 5-point scale (1: very unlikely, 2: unlikely, 3: neither, 4: likely, and 5: very likely). Part 4 collected their personal information.

There were seven surveyors who were trained to correctly administer the questionnaire. They also conducted a pilot survey to enhance their practice. They looked for Remork drivers by visiting many places around the city, including pickup/parking stations, major intersections, terminals, markets, schools, hotels, and other public locations. We adopted a simple random sampling procedure; rather than requesting every driver the surveyors saw to participate in the survey, the surveyors would randomly invite only a few drivers at each particular location (e.g., pickup/parking station where the drivers were standing by and waiting for imminent customers) for the interview. A potential sampling bias could be that the surveyors may reach many places where Remork drivers could be easily spotted, while the surveyors could find only a few drivers on smaller roads or in more distant suburban areas. However, the efforts to visit many places for respondents contributed to a broader geographical sampling distribution across the city, and thus, more diverse information could be gathered from representative Remork drivers. Under the time and financial constraints, the surveyors attempted to maximize the number of respondents during the survey period.

The surveyors requested approximately 257 Remork drivers around Phnom Penh, but only 200 drivers voluntarily participated in the survey (response rate of 77.8%). The reasons why drivers refused to join the survey include being busy, tired, and waiting for imminent customers. Some were also concerned that the surveyors could be a promoter for a company or politician. During the COVID-19 pandemic, despite the fact that the surveyors were taking proper protective measures (i.e., wearing a face mask, disinfecting hands with sanitizer, and keeping a safe physical distance), five drivers did not want to answer the questionnaire because they were afraid of potential infections. In a survey, a higher non-response rate may lead to a sampling bias that increases with the size of the non-responding group. The non-response bias in this survey is potentially minimized by several factors: 1) a simple random sampling technique was used across a wider geographical area, 2) the characteristics of the sample in this study are similar to those in an earlier study by Phun et al. (2020)—i.e., most respondents were 31–60 years old (92.0% vs. 89.7%) and married (95.7% vs. 98.3%), and 3) the response rate of 77.8% is considered high for face-to-face interview survey activities conducted during the COVID-19 pandemic—this is because average citizens may be less likely to take the risk of participating in a survey due to the pandemic.

The surveyors offered an incentive—a pack of face masks or a pen—to each interviewed Remork driver. The majority of the drivers preferred a face mask to a pen to reduce the risk of contracting COVID-19. Respondents spent 10–18 min on average answering the questionnaire. After the information screening process, there were only 186 samples usable for further analysis.

3.2. Respondent characteristics

The characteristics of respondents are reported in Table 1. All of the interviewed Remork drivers were male, with an average age of 46.8. The majority were aged between 31 and 60 years old (92.0%), were married (95.7%), and had a smartphone (81.2%). Their working duration as a Remork driver ranged from 1 to 20 years, with an average of 8.1 years. The minority had a driving license (30.1%), a dual job (18.3%), membership in a labor union (14.0%), and insurance (2.2%).
neither, 4: likely, 5: very likely). Fig. 2 reports their responses to 11 subjective questionnaire items related to the general impact of the COVID-19 pandemic, their precautionary measures, and their career satisfaction. The majority of drivers indicated high scores of 4 or 5 for Item 1 (96.7%) and Item 2 (80.6%), indicating that the advent of COVID-19 has had a strong negative effect on their operational services.

The majority reported that they worry about becoming infected when their customers sneeze or cough (75.8% rated scores of 4 or 5 for Item 5) and stated that they always protected themselves by wearing face masks, washing their hands, and keeping their physical distance (92.5% rated scores of 4 or 5 for Item 6). Of the participants, 37.1% (Item 7) reported that they had received sufficient equipment (masks and hand sanitizer) and necessary services to protect themselves during the pandemic. During the COVID-19 pandemic period, these informal drivers faced a high risk of infection as they continued to provide transport services and were more exposed to the general public than some other jobs including vehicle mechanics, bakers, and cleaners. Due to this situation, they should be regarded as key workers who deserve to receive substantial care. They seem to have expected some form of support (e.g., services and equipment to protect themselves against the pandemic) from others, including the government.

Although the majority claimed that they like their careers as Remork drivers (80.1%) and enjoyed the freedom that came with this career (88.7%), only 31.7% (scores 4 or 5 for Item 10) appeared satisfied with their living conditions. Despite the presence of the pandemic, however, the majority of drivers (90.9% rated scores of 4 or 5 for Item 11) still intended to continue serving the general public.

4.2. Before versus during the COVID-19 pandemic

The interviewed Remork drivers were also asked to indicate the arrival time of the COVID-19 pandemic in Cambodia in Part 2 of the questionnaire. We did not fix the event to one specific date. Instead, we allowed individual drivers to report their own perceived arrival time of the COVID-19 pandemic. The first COVID-19 cases were discovered in December 2019 in Wuhan, China. In Cambodia, the Ministry of Health publicly announced the first confirmed case of COVID-19 on January 27, 2020. The WHO then declared COVID-19 a global pandemic on March 11, 2020. This news, however, might not have been heard by many people, especially LAMAT drivers—this resulted in the different arrival times perceived by many Remork drivers. As a result, various times were reported and categorized into “late 2019” and “early 2020.” The respondents perceived that the COVID-19 pandemic arrived in Cambodia in late 2019 (approximately 16.0%) or early 2020 (84.0%).

Next, the interviewed Remork drivers were asked to report on their operational services both before and during the COVID-19 pandemic. In this case, the drivers were told to use their individual perceived arrival time as a reference time. This meant recalling their operational services in two different periods: before and after the advent of the COVID-19 pandemic. The summary of their operational services and comparison results are reported in Table 2.

On average, before the advent of the COVID-19 pandemic, Remork drivers worked about 11 h per day with 35.2 min for a lunch break, made 6.5 trips, and transported 8.8 passengers. Their monthly incomes ranged from 100 USD to 975 USD, with an average of 448.50 USD. At the same time, they spent from 30 USD to 337.50 USD on operational costs, ranging from 100 USD to 975 USD, with an average of 448.50 USD. At the same time, they spent from 30 USD to 337.50 USD on operational costs,
with an average of 112.70 USD per month. With regard to cruising behaviors, around 46% of Remork drivers reported trying to look for passengers along the city streets—these drivers cruised an average of 2.7 times and spent an average of 48.6 min daily.

Next, we will investigate the changes in the operational services of old-style Remork drivers following the advent of the COVID-19 pandemic. The changes were computed based on the relative difference in their operational services—i.e., Diff = ([Mean 2 – Mean 1]/Mean 1). The negative value of Diff suggests a decline in Mean 2 (i.e., the mean value after the advent of the COVID-19 pandemic) relative to Mean 1 (i.e., the mean value before the advent of the COVID-19 pandemic). The results from paired t-tests revealed significant changes in most variables in Table 2 (p < 0.05), except for the variables of cruising behavior (p > 0.05). The average daily operating hours declined from 11.0 h to 10.4 h—this is equivalent to a decline of 5.9% [(10.4–11.0)/11.0]—while the average time spent for a lunch break each day increased by 15.9%. These findings suggest that, during the COVID-19 pandemic, Remork drivers seemed to work shorter hours while resting more. Further, the average number of daily trips and passengers were found to decline by 55.5% and 57.3%, respectively. Accordingly, there was also a decrease in the drivers’ income by 52.5%—their average income decreased from 448.50 USD to 212.90 USD per month. The fewer trips and shorter servicing hours each day led to not only a lower monthly income but also a 25.5% reduction in monthly operational costs (expenses). To this end, the comparison results initially suggest that the advent of the COVID-19 pandemic had a negative influence on the operational services of old-style LAMAT transportation (i.e., Remork).

Noted that the sample size was reduced to 186 because we focused only on passenger transport services via Remork. The excluded respondents were those drivers with zero passengers per day—usually, these drivers transported only cargo. These respondents could include those drivers who were originally transporting only cargo and those who might have shifted, under the COVID-19 pandemic, from transporting passengers to cargo.

4.3. Regression approach

To investigate the possible influence of the COVID-19 pandemic on the livelihood of old-style LAMAT drivers who have operated without registering themselves with an RHA in Phnom Penh (i.e., Remork drivers), we further applied a linear regression approach as follows:

\[ Y_i = \alpha + \gamma D_{AFT} + \theta X_i + \epsilon_i \]  \hspace{1cm} (1)

\[ Y_i = \alpha + \gamma D_{AFT} + \theta X_i + u_i + \epsilon_i \]  \hspace{1cm} (2)

where \( Y_i \) is the dependent variable or an indicator of the Remork driver \( i \) at Year \( t; D_{AFT} \) is a temporal dummy variable (equals 1: if the time is during the COVID-19 pandemic; 0: otherwise; \( X_i \) is a vector of covariates for driver \( i \) at Year \( t; \alpha, \gamma, \) and \( \theta \) are parameters to be estimated; and \( \epsilon_i \) is the error term. Eq. (1) is the simple log-linear regression. This may be regarded as a simple regression discontinuity design approach (Imbens and Lemieux, 2008) for evaluating the causal effects of a given event. Eq. (2) is a fixed-effects model. The two error terms "\( u_i \) and \( \epsilon_i \)" behave somewhat differently (Allison, 2006). There is a different \( \epsilon_i \) for each individual driver at each point in time (before and during COVID-19), but \( u_i \) only varies across individuals, not over time. The error term \( u_i \) is regarded as the representative of the combined effect on \( Y \) of all unobserved variables that are constant over time, while \( \epsilon_i \) represents purely random variation at each point in time. The fixed-effects estimator allows for arbitrary correlation between \( u_i \) and the explanatory variables in any time period (Woolridge, 2013). Eq. (2) becomes a random-effects model when the unobserved effect \( u_i \) is assumed to be uncorrelated with each explanatory variable, \( \text{Cov}(X_{it}, u_i) = 0 \) (Woolridge, 2013).

We further considered the fixed-effects and random-effects models in Eq. (2) because these models would capture the impact of time-varying predictors (e.g., working hours, trip frequency) and time-invariant predictors (e.g., age, marital status) on the dependent variable (i.e., monthly income) before and during COVID-19. The data collected in this study contains the repeated measures (i.e., monthly income, working hours, trip frequency, number of passengers, cruising frequency, expense on COVID-19 protection) on the same respondents before and during COVID-19, which would be considered panel data—so the analysis using this panel data might need control of some biases, particularly unmeasured confounding. These biases would occur if the time-varying predictors depend on the time-invariant predictors. Various specifications were tested for the models, using different possible combinations of explanatory variables. The summary statistics of the variables used in the regression model are reported in Table 3. The total number of observations becomes \( n = 372 (= 186 \times 2) \) because each respondent answered regarding the LAMAT’s operational services (e.g.,

### Table 2

| Variables                        | N  | Before the advent of COVID-19 | After the advent of COVID-19 | Comparison of mean |
|----------------------------------|----|-------------------------------|-----------------------------|--------------------|
|                                 |    | Mean | SD | Min | Max | Mean | SD | Min | Max | Diff | DF | p-test |
| Daily working duration, in hours | 186 | 11.00 | 3.40 | 3 | 24 | 10.35 | 3.86 | 2 | 24 | 5.9% | 185 | <0.01  |
| Daily lunch break, in minutes   | 186 | 35.18 | 29.02 | 7.5 | 180 | 40.78 | 33.28 | 10 | 180 | 15.0% | 185 | <0.01  |
| Number of daily trips           | 186 | 6.54  | 3.12 | 1 | 18 | 2.91  | 1.85 | 0.3 | 11 | 55.5% | 185 | <0.01  |
| Number of daily passengers      | 186 | 8.83  | 4.25 | 1 | 30 | 3.77  | 2.12 | 1 | 12 | 57.3% | 185 | <0.01  |
| Monthly income, in USD          | 186 | 448.52| 155.65 | 100 | 975 | 212.89| 111.70| 37.5 | 550 | 52.5% | 185 | 0.018  |
| Monthly expenses, in USD        | 186 | 112.70| 48.27 | 30 | 337.5| 83.95 | 45.01 | 20 | 300 | 25.3% | 185 | <0.01  |
| Whether to cruise for passengers| 186 | 0.46  | 0.50 | 0 | 1 | 0.43  | 0.50 | 0 | 1 | 6.5%  | 185 | <0.01  |
| Freq. of cruising for passengers | 93  | 2.66  | 1.73 | 0 | 10 | 2.77  | 2.13 | 0 | 10 | 4.1%  | 92  | 0.57   |
| Duration of cruising, in minutes| 93  | 48.58 | 50.74 | 0 | 240| 55.72 | 65.00 | 0 | 240| 14.7% | 92  | 1.63   |

Note: Before and After were relative to each individual’s perceived arrival time of the COVID-19 pandemic in Cambodia. SD: standard deviation, Diff: proportional difference between after and before the advent of the COVID-19 pandemic. 

*p < 0.1, **p < 0.05, ***p < 0.01.

### Table 3

| Variable                          | Mean | SD | Min | Max |
|-----------------------------------|------|----|-----|-----|
| Income (USD per month)            | 330.70| 179.50| 37.5 | 975  |
| ln(Income) (natural logarithm of income) | 5.63  | 0.63 | 3.62 | 6.88  |
| D_AFT (1: if during the COVID-19 pandemic, 0: otherwise) | 0.50  | 0.50 | 0.00 | 1.00  |
| Working hours (hours per day)     | 10.67 | 3.65 | 2 | 24 |
| Trip frequency (trips per day)    | 4.72  | 3.14 | 0.3 | 18 |
| Passengers (persons per day)      | 6.30  | 4.20 | 1 | 30 |
| Cruising frequency (times per day)| 1.36  | 1.93 | 0 | 10 |
| D_Parking (1: if with a pickup station, 0: otherwise) | 0.66  | 0.47 | 0 | 1 |
| Expense of COVID-19 protection (USD per month) | 6.54  | 6.22 | 0 | 50 |
| Age                               | 46.76 | 8.90 | 26 | 72 |
| D_Married (1: if married, 0: otherwise) | 0.96  | 0.20 | 0 | 1 |

The changes in Remork services before vs. after the advent of the COVID-19 pandemic and corresponding comparison results using paired t-tests.
income, working hours) before and after the advent of the COVID-19 pandemic.

Table 4 reports the estimated results for three regression models: Model 1 is the simple log-linear regression, using the Ordinary Least Square (OLS) estimator; Model 2 is fixed-effects regression, using the fixed-effects (within) regression estimator; and Model 3 is random-effects regression, using the General Least Square random-effects estimator. To decide which model is suitable to explain the possible influence of the COVID-19 pandemic on Remork services, we attempted to compare the models.

First, to decide between the fixed-effects or random-effects models, the Hausman test was performed. It tests whether the unique errors (ui) are correlated with explanatory variables; the null hypothesis (H0) is that they are not (Green, 2008). Results showed that we failed to reject the H0 [\( \chi^2 (5) = 8.04, p = 0.1540 \)] —and the random-effects model is therefore preferred. The intraclass correlation (\( \rho \)) indicates that 40.52% of the variance is due to differences across panels. However, the interpretation of the estimated coefficients of the random-effects model is somehow complicated because these coefficients include both the within-entity and between-entity effects (Torres-Reyna, 2007). In this study, the coefficient represents the average effect of \( X \) over \( Y \) when \( X \) changes across time and between individuals by one unit. However, we could not directly compare the goodness-of-fit (\( R^2 \)) values across models. The reported \( R^2 \) in the fixed-effects model (Model 2) and random-effects model (Model 3) did not have all the properties of the OLS \( R^2 \) (Model 1), and thus, they should not be compared (Wooldridge, 2013). To this end, we prefer to explain the possible influence of the COVID-19 pandemic on old-style Remork services in Phnom Penh based on the estimate results from the semi-log regression model (Model 1) for two reasons: 1) the estimated coefficients from Model 3 are similar to those from Model 1 (i.e., coefficient values, coefficient signs, and significance); and 2) the semi-long specification allows the interpretation of regression coefficients as the percentage change due to the marginal increase in the value of explanatory variables (Phun and Chalermpong, 2010).

Model 1 fits the data reasonably well, with the \( R^2 \) values of 55.95%. All variables included in the model are statistically significant with expected signs (\( p < 0.1 \)). The dummy variable D_AFT—which equals 1 if the time was after the advent of the COVID-19 pandemic and 0 if otherwise—could possibly be used as a proxy variable to explain the possible influence of the pandemic on Remork drivers’ income. The estimated coefficients of D_AFT are negatively significant (\( p < 0.01 \)), indicating that drivers’ income decreased by 61.77% after the advent of the COVID-19 pandemic, *ceteris paribus*.

The coefficient of daily working hours is significantly positive (\( p < 0.1 \)), suggesting that Remork drivers could earn 1.30% more monthly income for every one extra hour of work per day, other factors being equal. Similarly, they could increase their monthly income by 3.85% for every one additional trip that they could make per day (\( p < 0.01 \)). They could also increase their monthly income by 1.23% for every one extra passenger per day (\( p < 0.05 \)). These results are plausible since drivers who worked longer hours per day would also be able to make more daily trips and transport more passengers, and thus, they would be able to increase their monthly income.

The coefficients for Cruising frequency and D_Parking are significantly negative (\( p < 0.05 \)). The results indicate that, although Remork drivers tried to get more customers by cruising along the road more frequently, they ended up with a lower income (by 3.01% per cruise). Likewise, there is a reduction in monthly income by 17.14% for drivers with a secured parking station (or pickup station). The lower incomes may be associated with the operational costs for every cruise activity they made and with the fee they must pay to secure a parking station. As fewer citizens travel in the city during the COVID-19 situation, more operational costs would lead to lower income.

In terms of protective measures against COVID-19, the positively significant coefficient of Expense of COVID-19 protection (\( p < 0.1 \)) explains that the drivers could actually increase their monthly income by 0.88% if they spent one extra USD per month on health-protecting gear (e.g., face masks and hand sanitizer). This is reasonable because passengers during the COVID-19 pandemic would prefer to use Remork services provided by drivers with better health-protection equipment.

The coefficient of Age is negatively significant (\( p < 0.01 \)), suggesting that drivers who were one year older experienced a 0.81% decline in their monthly income. One possible explanation is that the older drivers may have less enthusiasm for finding more passengers during the pandemic, or the pandemic itself created an environment in which the older drivers encountered fewer passengers. The coefficient of D_Married is positively significant (\( p < 0.01 \)), suggesting that married drivers could earn 39.05% more than those who had not yet gotten married. This might be due to the fact that married drivers tend to work harder to earn more income to support their families.

It should be noted that, although the Remork services may have been influenced by the advent of RHAs (Phun et al., 2020) prior to the COVID-19 outbreak in Cambodia, this influence was not considered in

### Table 4

| Variable                  | Model 1 | Model 2 | Model 3 |
|---------------------------|---------|---------|---------|
| Intercept                 | 0.0888  | *       | 0.0886  |
| Expense of COVID-19       | (0.0045)|         | (0.0046)|
| Protection               | (0.0028)|         | (0.0052)|
| Age                      | (0.0081)| ***     | (0.0082)|
| D_Married                | (0.3905)| ***     | 0.3903  |
| D_Parking                | (0.1383)|         | (0.1332)|
| Cruise frequency          | 5.6427  | ***     | 27.8100 |***
|                           | (0.2158)|         | (0.1957)|
| Observations              | 372     | 372     | 372     |
| F (9, 362)                | 127.80  | −0.997  | 685.62  |
| Prob. > F                | 0.5595  | 0.0000  | 0.0000  |
| R² within                 | 0.7793  | 0.7742  | 0.7742  |
| R² between               | 0.0673  | 0.2481  | 0.2481  |
| R² overall               | 0.4703  | 0.5581  | 0.5581  |
| σ_u                      | 0.4032  | 0.2710  | 0.2710  |
| σ_v                      | 0.3283  | 0.3283  | 0.3283  |
| ρ                        | 0.6013  | 0.3283  | 0.3283  |

Note: The standard errors are enclosed in parentheses. The robust standard errors are italics enclosed in parentheses. σ_u is the standard deviation of residuals within group \( u_t \). σ_v is the standard deviation of residuals (overall error term) \( e_{it} \). ρ = \( \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \) is the intraclass correlation. \( \ast p < 0.1, \ast\ast p < 0.05, \ast\ast\ast p < 0.01 \).
this study. This is because we wanted to capture only the possible influences of the pandemic on Remork services. Accordingly, the interviewed Remork drivers were requested to report only the changes in their operational services before and during the COVID-19 pandemic without mentioning the influence of RHAs.

5. Discussion

As we could anticipate a negative impact of the COVID-19 pandemic on public transport services, including Remork drivers, we searched for a better understanding of the challenges that Remork drivers might face during the COVID-19 pandemic. The interviewed Remork drivers were asked to freely report three main difficulties/challenges they faced when operating in the pandemic context. A total of 367 mixed responses were received and classified into the categories shown in Fig. 3 (left). About 14.2% reported that they were afraid of COVID-19 infection. The majority (75.5%) reported a decline in the number of passengers and a decrease in income, suggesting that they had considerable concern over their living conditions in light of the current COVID-19 pandemic circumstances. Following the decline in their passengers and income, about 8.7% were facing a financial challenge, such as the need to pay a bank loan. This is compelling because these drivers required the revenue from their daily Remork services to pay the bank loan.

At the end of the questionnaire, we also requested that the interviewed Remork drivers state three important opinions, addressed to the government and relevant authorities, regarding their driving career—especially during the COVID-19 pandemic. A total of 196 responses were received and classified into the categories shown in Fig. 3 (right). As a response to COVID-19, 6.6% of drivers expected to receive support such as vaccination and protective gear (masks and hand sanitizer) to stop COVID-19. In response to their major difficulties during the pandemic, 23.0% of Remork drivers demanded financial support. The mentioned financial support included assistance with bank loans, social welfare (e.g., financial support, monthly subsidy), and lower prices for general goods and gasoline. The majority (65.8%) called for a regulatory framework to support Remork services. Related requests included a control on Bajaj growth (their main competitor), the creation of policies to facilitate parking and passenger pickup, decreased interference from traffic police, and an effort to preserve Remarks (just like the case of cyclos).

The old-style transport services provided by Remork drivers in Phnom Penh have been affected by two major events. First is the fast-growing popularity of Bajaj services with RHAs over the old-style Remork services. The arrival of RHAs has had a considerable effect on the transport services provided by Remork drivers, who have operated without an RHA, as reported in Phun et al. (2020). Second, COVID-19 has had a negative effect on the operational services of Remork drivers, as found in this study. In Cambodia, whether it is an effective environment. In a wider scope, Zhang (2020) discussed relevant transport policies in the COVID-19 context as well as the future public health implications.

However, this study revealed the negative influence of the COVID-19 pandemic on the livelihood of Remork drivers (i.e., Remork drivers). As for the managerial implications (based on the findings in Fig. 3), we recommend that the government should consider an immediate intervention via minimum support to facilitate the informal transport operators and their services (i.e., Remork drivers), particularly during the COVID-19 pandemic period. The support should begin with the provision of protective gear (e.g., masks, hand sanitizer, vaccination), indirect financial care (e.g., lowering the price of gasoline and general goods, easing of bank loans), and growth control of the overall number of Remork operators in the city (supply side). This type of minimal support should also be considered in other developing Asian cities where REMARK operators (e.g., Bajaj, tuk-tuks, jeepsneys, taxis) have been facing difficulties related to demand during the COVID-19 pandemic. This is because REMARK drivers are key workers who appear to have a higher risk of COVID-19 infection and spread due to their exposure. Lastly, REMARK supports socio-economic activities by providing employment stability to low-skilled individuals and the through the available REMARK services themselves (especially in places with a lack of public transport services). In line with this situation, the provision of protective gear to REMARK drivers during the COVID-19 pandemic is urgently needed to reduce the spread of the disease while facilitating REMARK operations and services during the new normal.

6. Conclusion

This study explored the influence of the COVID-19 pandemic on old-style Remork services in Phnom Penh. The influence was investigated using various approaches to analyze the survey data collected from 186 Remork drivers from December 25–28, 2020. The results from this study suggested that the COVID-19 pandemic had a negative influence on the operational services of Remork drivers. This negative influence was confirmed by the results from at least four different data analyses: (i) the subjective responses in Fig. 2 suggest that most drivers (96.2%) perceived a strong negative influence of the COVID-19 pandemic on their operational services; (ii) The majority (75.5%) of Remork drivers in Fig. 3 (left) expressed their difficulties, indicating that they transported fewer passengers and received a lower income during the pandemic; (iii) the results from paired t-tests in Table 2 indicate that—when we compared Remork drivers’ operational services before and during the COVID-19 pandemic—there were significant declines (p < 0.01) in their daily trip frequency (55.5%), the number of daily passengers (57.3%), and monthly income (52.5), and (iv) the estimated results from regression analyses (Model 1) in Table 4 indicate a lower monthly income by 61.77% (i.e., coefficient of $D_{AFT}$, $p < 0.01$). These results affirm the potentially negative influence of the COVID-19 pandemic on the operational services of REMARK operators and drivers in Phnom Penh. Because the effect of the COVID-19 pandemic itself is broad and overlaps with other circumstances, it is not easy to say that the COVID-19 pandemic has had a direct impact on REMARK services. Following the advent of the COVID-19 pandemic and a decline in overall urban mobility in Phnom Penh, this study thus attempts to understand the changes rather than examining the precise impact of COVID-19 on REMARK’s operational services. The results found from the Phnom Penh case may reflect the situation in other developing cities of Asia, where citizens mainly depend on REMARK services and where the COVID-19 pandemic is still an urgent situation. The minimum support (e.g., protective gear, financial support) should be provided to the impacted drivers during the pandemic, so that they could continue to provide transport service to many people in need.

The COVID-19 outbreak has created an unprecedented impact on citizens, resulting in alternatives (e.g., teleworking, online classroom, or shopping) to avoid unnecessary travel. Such alternatives could reduce...
travel demand, which in turn has a considerable influence on urban mobility in general as well as on modal shift in the long run. Given the situation that the COVID-19 pandemic continues to prolong, citizens may soon live in the new normal environment. Public transport systems (e.g., public bus, urban rail) would provide limited transport services to the general public (with restrictions such as physical distancing within the transit vehicle) or would be further suspended to lessen the impact of the pandemic. Such a situation would produce some demand for LAMAT services. With the available LAMAT services, LAMAT drivers should be equipped with sufficient protective gear (e.g., face masks, vaccination) in order to ensure a lower risk of COVID-19 for both drivers and customers. Under the new normal environment, however, more citizens may prefer personal transport modes (e.g., cars, motorbikes, bicycles, walking) to avoid the risks associated with crowded places, social distancing norms, and trips with strangers (e.g., LAMAT drivers, public buses). As the circumstances of the COVID-19 pandemic continue, although many interviewed drivers (90.9%) intended to continue driving Remarks, they may face more difficult living conditions. Future studies should investigate the drivers’ livelihoods and whether they intend to change from their career as Remark drivers to other jobs. Finally, a review and draft summary of the minimal regulation for LAMAT services during the COVID-19 pandemic would be useful for the government in formulating national strategies for minimizing the virus spread in the new normal scenario.

Declaration of competing interest

We, the author and co-authors of this manuscript, entitled “Influence of the COVID-19 Pandemic on Old-Style LAMAT Services in Developing Cities of Asia: The Case Study of Phnom Penh”, declare no conflict of interest.

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