

# LAST-MILE DELIVERY SERVICES: INVESTIGATING THE RISKS FOR CARGO MOTORCYCLE DRIVERS

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## **ABSTRACT**

**Research purpose:** This research aims to identify both internal and external risk factors affecting motorcycle cargo drivers and evaluate their frequency and impact levels from the perception of motorcycle cargo drivers.

**Methodology:** Based on the direct behaviour interview survey conducted in Hanoi, respondents from four e-commerce companies (Shopee, Lazada, Tiki, Sendo), six delivery companies (Giao Hang Nhanh, Giao Hang Tiet Kiem, Ninja Van, Kerry Logistics, Viettel Post, Nhat Tin) and two food-delivery companies (Shopee Food, Grab Food) were collected. The Risk Breakdown Structure (RBS) is selected for risk analysis, focusing on both occurrence probability and impact severity.

**Findings:** Results indicate that almost 25% of motorcycle cargo drivers reported being involved in at least one accident during the last 12 months. Of these, almost 90% indicated that traffic flow, road infrastructure, weather condition, and riding behaviour affect their road crashes. The study found that traffic flow, infrastructure conditions, environmental issues, and risky riding behaviours contribute to the possible accidents from the shipper's perception.

**Value:** The study provides empirical evidence to logistics service providers and urban transport planners to improve the traffic safety and level of service of urban logistics.

**Keywords:** Urban Logistics; E-Logistics; Last-mile Delivery; Logistics Services; Cargo Motorcycle Driver

## **Introduction**

Cargo motorcycle drivers are people who use their motorcycles to deliver cargo or food to the end customers. This service is gradually popular in many cities in Asian countries due to the rapid development of e-commerce. Motorcycle riders are involved greatly in last-mile delivery since motorcycles have exceptional advantages of accessibility and mobility. Motorcycles can access houses and departments of customers who live in small alleys where small trucks hardly access. Moreover, due to the congestion in big cities, the riding time of a motorcycle can be more competitive than a truck within an equivalent distance. However, cargo motorcycle drivers often face many transport risks due to traffic congestion, the slippery road surface under the rain, the hot and humid weather in summer, and their hurry mentality to fulfil the delivery requirements. A study by Taniguchi, et. al. (2010) provided an overview of how to include risks from both natural and behavioural risks in city logistics modelling (Taniguchi et al., 2010). Their findings indicated that many accidents and crashes relating to food and cargo delivery are associated with transport risks. Various studies have revealed that unsafe travel situations are major causes of traffic accidents and crashes to motorcycle riders and cargo riders. A study of motorcycle food delivery professionals in Chiang Rai Province, Thailand shows that risky riding behaviours and the lack of safety equipment are major causes of travelling crashes (Arreeras et al., 2022). Similarly, research by Han Byun J, et. al. (2017) in Korea analysed the data on motorcycle crashes of 1,310 food delivery workers (Han Byun et al., 2017).

Such studies investigated factors associated with road accidents of traditional and app-based motorcycle taxi drivers, cargo last-mile delivery riders and food delivery. However, the limitations of these papers are that self-related risks are major focuses, especially the risky driving behaviour of motorcycle riders. Road accidents and crashes result from both internal and external risks, of which the road infrastructure, traffic flow, environmental issues, and riding behaviour are entirely involved. This research aims to identify both internal and external risk factors affecting the riding crashes of cargo motorcycle drivers and evaluate their frequency and impact levels from cargo motorcycle riders' perception. For this purpose, cargo motorcycle drivers were selected for the survey. The next section examines previous studies on the traffic risks of motorcycle riders. The experimental design and data collection are described in Section 3. Section 4 explains the data analysis and discussion, and the conclusions are presented in Section 5.

## Review of Risk Factors

Risk is defined as the likelihood of loss (Hillson, 2003). Risk-related research has started to increase in the logistics and transport sector. Risk is a significant concern because it frequently is linked to reliability, efficiency, and safety in transport (Masár et al., 2019). Identification, analysis, and mitigation of risk are steps in the decision-making process involved in risk management. The Risk Breakdown Structure (RBS) method, which was adapted from the Work Breakdown Structure (WBS) used in project management, is used to identify risks. Risk-based risks can be properly defined and categorized for each level using RBS (Hallowell et al., 2013). Each risk is categorized using RBS. RBS is a collection of risks arranged logically, methodically, and systematically to form a traffic-related risk hierarchy.

The research evidence implies that drivers of cars generally incur lower transport dangers than those who ride motorcycles. The main reason for this is that motorcycle riders are not protected in collisions (Chen, 2009; Lin and Kraus, 2009); also, they are more likely to take risks, increasing the number of motorcycle-related fatalities (Rifaat et al., 2012). Numerous studies have been published in the literature that have revealed a wide variety of traffic risks related to riding behaviour, traffic flow, road infrastructure, and weather extremes. These are covered in this section. Table 1 provides a summary.

| Risk Type                      | Code | Actual Traffic Risks    | Explanation   | Sources   |
|--------------------------------|------|-------------------------|---|---|
| Riding behaviour-related risks | RB1  | Excessive speed         | Riding over permitted speed*  | (Quy Nguyen-Phuoc et al., 2023; Tran et al., 2022)        |
|                                | RB2  | Mobile using            | Using a mobile phone while riding   | (Eustace et al., 2011), (Arreeras et al., 2022)           |
|                                | RB3  | Ignoring road sign      | Disregarding the road sign and notice during delivery riding                                    | (Truong et al., 2020), (Rifaat et al., 2012)              |
|                                | RB4  | Red light pass          | Riding over a red light at the intersection   | (Lin and Kraus, 2009), (Chen, 2009)                       |
|                                | RB5  | Bulky cargo             | Carrying bulky and over-weighted parcels  | (Horwood and Fergusson, 2000), (Iversen and Rundmo, 2002) |
| Traffic flow-related risks     | TC1  | Traffic congestion      | The congested traffic flow due to the high volume of vehicles                                   | (Golob and Recker, 2004)                                  |
|                                | TC2  | Lane rearrangement      | The re-arrange of road lanes and other unexpected traffic organization due to traffic incidents | (Nguyen-Phuoc et al., 2020; Tsubota et al., 2018)         |
| Infrastructu re-related risks  | IF1  | Bumpy road              | Poor road condition due to the road is not maintained regularly                                 | (Fridstrøm et al., 1995; Tsubota et al., 2018)            |
|                                | IF2  | Slippery and muddy road | Deposit on the road as oil, or mud...due to unexpected material dropping or truck crashing      | (Arreeras et al., 2022; Lin and Kraus, 2009)              |
|                                | IF3  | Poor road lighting      | Poor light conditions along the roads at night or during dark day-light                         | (Chen, 2009; Iversen and Rundmo, 2002)                    |
| Weather-related risks          | WE1  | Rainy weather           | Flood or slippery conditions due to heavy rain  | (Brodsky and Hakkert, 1988; Keay and Simmonds, 2005)      |
|                                | WE2  | Hot weather             | Strong hot and humid weather in the summer season   | (Fridstrøm et al., 1995; Tsubota et al., 2018)            |

\* Under the Vietnamese Road Traffic Law, the maximum speed for motorcycles when travelling in densely populated areas is regulated at 50km/h or 60km/h under a certain road type and number of lanes.

Table 1: Risk Breakdown Structure (RBS) for motorcycle crashes

Such literature provides a basic understanding of the possible transport risks for cargo motorcycle drivers, especially cargo motorcycle drivers in megacities such as Hanoi. The selected risks from the literature are designed for the RBS (Table 1), and then based on that RBS, the Cargo Motorcycle Rider Behaviour Questionnaires are developed to investigate and rank the transport risks from a cargo motorcycle rider's perspective.

## **Methodology**

### **Survey design and data collection**

About 7.3 million people are living in Hanoi, which serves as Vietnam's capital. In 2023, around 710 people are dead in traffic accidents in Hanoi (Ngoc and My Thanh, 2020). In Hanoi, where traffic is dominated by motorcycle riders (Ngoc and Thanh, 2020). This study utilizes information from a structured questionnaire survey of cargo motorcycle drivers that was conducted between May and June 2022. Based on the direct behaviour interview, 466 cargo motorcycle rider respondents (as shown in Table 2) from four e-commerce companies (Shopee, Lazada, Tiki, Sendo), six delivery companies (Giao Hang Nhanh, Giao Hang Tiet Kiem, Ninja Van, Kerry Logistics, Viettel Post, Nhat Tin) and two food-delivery companies (Shopee Food, Grab Food) were collected.

The interview collected the information of age, gender, degree of education, and income of respondents. They were also asked to provide the typical daily riding and working hours, considering waiting time. They disclosed their average weekly delivery travels and the number of years they worked as cargo motorcycle riders. Additionally, respondents were asked to mark their employment status (full-time or part-time). The survey questionnaire also gathered information from cargo motorcycle drivers about their road traffic accidents or slips and falls over the previous 12 months (self-reported). Based on survey questionnaires, cargo motorcycle drivers also evaluated the transport risks that occurred during their working travel, both the occurrence frequency (measured on a 5-point Likert scale from rare = 1 to certain = 5) and the impact severity (also measured on a 5-point Likert scale from low = 1 to high = 5).

### **Sample characteristics**

Only 2.58% of the 466 cargo motorcycle drivers were female. Many females responded that motorcycling is often associated with risks and safety concerns. Women perceive it as a more dangerous occupation due to factors such as traffic accidents, physical demands, and potential harassment or assault during deliveries. Concerns about personal safety can deter women from pursuing this line of work. The average age of cargo motorcycle drivers was 27.1, ranging from 18 to 62 years old. Approximately 61.6% of them either completed or were pursuing education above the high school level (i.e. universities or vocation). Nearly 65% of the cargo motorcycle drivers worked part-time. Motorcycle shipping services enabled many drivers to work part-time or as casual workers. The average cargo motorcycle rider rode for work between 501 and 750 kilometres per week, and between 251 and 500 kilometres per week, respectively.

| <b>Attributes</b>     | <b>Level Range</b> | <b>n</b> | <b>(%)</b> |
|-----------------------|--------------------|----------|------------|
| Number of respondents |                    |          | 466        |
| Gender                | Male               | 454      | 97,42      |
|                       | Female             | 12       | 2,58       |
| Working status        | Full time          | 162      | 34,76      |
|                       | Part-time          | 304      | 65,24      |
| Age                   | 18–29              | 197      | 42,20      |
|                       | 30–39              | 168      | 36,12      |
|                       | 40–49              | 92       | 19,70      |
|                       | 50–59              | 8        | 1,80       |
|                       | 60 and over        | 1        | 0,18       |

|                          |                                  |     |       |
|--------------------------|----------------------------------|-----|-------|
| Education                | High school or under             | 179 | 38,40 |
|                          | University/Vocation (in process) | 225 | 48,21 |
|                          | University/Vocation (graduated)  | 62  | 13,39 |
| Monthly household income | <3 million VND/month             | 3   | 0,69  |
|                          | 3 ~ < 6 million VND/month        | 13  | 2,80  |
|                          | 6 ~ < 10 million VND/month       | 181 | 38,77 |
|                          | 10 ~ <20 million VND/month       | 216 | 46,28 |
|                          | 20 ~ 40 million VND/month        | 47  | 10,12 |
|                          | > 40 million VND/month           | 6   | 1,34  |

\* VND – Vietnamese Dong, 1 USD = 23,375 VND (December, 2022)

Table 2: Descriptive statistics of respondents

| Variables                            | Average | Std.   |
|--------------------------------------|---------|--------|
| Shipping experience (years)          | 1,21    | 1,02   |
| Weekly delivery trips                | 112     | 69     |
| Daily working hours                  | 9,32    | 17,41  |
| Daily riding hours for work          | 7,11    | 2,88   |
| Weekly riding distance for work (km) | 412,66  | 206,52 |
| Crash frequency                      | 0,46    | 0,76   |

Table 3: Descriptive statistics of shipping trips (n = 466)

### Chi-Squared test

A statistical technique called the chi-squared test is used to identify statistical correlations between variables under the null hypothesis that there is no association between a set of groups and the responses they receive. The null hypothesis was rejected if the p-value was less than 0.05 since the significance level was set at 0.05. The test statistic was

$$\chi^2 = \sum_{i=1}^c \sum_{j=1}^r \frac{(O_{i,j} - E_{i,j})^2}{E_{i,j}} \quad (1)$$

and

$$E_{i,j} = \frac{n_i n_j}{N}$$

$\chi^2$  is Pearson's cumulative test statistic, which approaches a non-normal distribution with  $(r - 1)(c - 1)$ . Row variables had a degree of freedom, but column variables were independent.  $O_{i,j}$  denotes how many observations are present in row  $i$  and column  $j$ .  $E_{i,j}$  stands for the predicted frequency value in columns  $j$  and  $i$ . The number of cells in the table equals  $n$ , where  $n$  is the total number of observations. To examine the association between traffic risks and individual and trip variables for cargo transport, the chi-squared test was performed.

### Questionnaire reliability

As indicated in Table 4, the reliability or internal consistency of the barriers was assessed using Cronbach's alpha. It is advised that infrastructure, performance, and financial obstacles have Cronbach's alpha values over 0.70, which denotes high reliability (Ben-Akiva and Boccara, 1995). Technically, Cronbach's alpha is a reliability coefficient that may be determined using the following equation:

$$\alpha = \frac{k \times \bar{c}}{v + (k - 1)\bar{c}} \quad (2)$$

where  $\alpha$  refers to Cronbach's alpha;  $k$  is the number of items;  $c$  is the average of all covariance between items; and  $v$  is the average variance of each item.

| Risk Factors                   | Category                | Cronbach's Alpha |
|--------------------------------|-------------------------|------------------|
| Riding behaviour-related risks | RB1, RB2, RB3, RB4, RB5 | 0.766            |

|                              |               |       |
|------------------------------|---------------|-------|
| Traffic flow-related risks   | TC1, TC2      | 0.823 |
| Infrastructure-related risks | IF1, IF2, IF3 | 0.845 |
| Weather-related risks        | WE1, WE2      | 0.803 |

Table 4: Reliability of questionnaires among risk factors

### Results and Discussion

This paper has identified and evaluated the perception of possible internal and external risks involved in road crashes of cargo motorcycle drivers. Results indicate that almost 25% of cargo motorcycle drivers reported being involved in at least one accident during the last 12 months. Of these, almost 90% indicated that traffic flow, road infrastructure, weather condition, and riding behaviour simultaneously affect their road crashes.

### Ranking the transport risks from cargo drivers' perception

In Table 5 and Table 6, the results of the descriptive analysis are summarized. Considering risk occurrence frequency, it is observed that traffic congestion (TC1) had the highest average score for the risks of travel crashes from a cargo motorcycle rider's viewpoint, followed by bulky cargo (RB5). Weather-related risks are also a major concern of many cargo motorcycle drivers, with rainy and hot weather ranked as the third and the fourth level respectively. Riding a motorcycle for very long distances under the hot and humid, or rainy and slippery roads are big challenges to various cargo riders. Most respondents are concerned about both external and internal risks. The external risks consist of traffic flow and the carried heavy cargo which are hard to control. The internal risks, including using a mobile during riding and passing the red light, are mostly under the awareness of the cargo riders as their dangerous driving behaviour for delivery jobs.

| Risk ID | Traffic Risks           | Min | Max | Mean $\pm$ SD    | Rank occurrence frequency |
|---------|-------------------------|-----|-----|------------------|---------------------------|
| TC1     | Traffic congestion      | 1   | 5   | 4.22 $\pm$ 1.025 | 1                         |
| RB5     | Bulky cargo             | 1   | 5   | 4.18 $\pm$ 1.008 | 2                         |
| WE1     | Rainy weather           | 1   | 5   | 4.16 $\pm$ 1.062 | 3                         |
| WE2     | Hot weather             | 1   | 5   | 4.16 $\pm$ 1.046 | 3                         |
| IF1     | Bumpy road              | 1   | 5   | 4.14 $\pm$ 1.087 | 5                         |
| IF3     | Poor road lighting      | 1   | 5   | 4.06 $\pm$ 1.078 | 6                         |
| RB1     | Excessive speed         | 1   | 5   | 4.03 $\pm$ 1.122 | 7                         |
| RB2     | Mobile using            | 1   | 5   | 4.02 $\pm$ 1.127 | 8                         |
| IF2     | Slippery and muddy road | 1   | 5   | 3.97 $\pm$ 1.060 | 9                         |
| RB3     | Ignoring road sign      | 1   | 5   | 3.94 $\pm$ 1.064 | 10                        |
| TC2     | Lane re-arrangement     | 1   | 5   | 3.90 $\pm$ 1.155 | 11                        |
| RB4     | Red light pass          | 1   | 5   | 3.83 $\pm$ 1.115 | 12                        |

Table 5. Ranking the occurrence frequency of transport risks.

| Risk ID | Traffic Risks           | Min | Max | Mean $\pm$ SD    | Rank impact severity |
|---------|-------------------------|-----|-----|------------------|----------------------|
| RB4     | Red light pass          | 1   | 5   | 4.35 $\pm$ 1.003 | 1                    |
| IF2     | Slippery and muddy road | 1   | 5   | 4.12 $\pm$ 1.018 | 2                    |
| RB1     | Excessive speed         | 1   | 5   | 4.08 $\pm$ 1.044 | 3                    |
| TC1     | Traffic congestion      | 1   | 5   | 4.03 $\pm$ 1.034 | 4                    |
| RB5     | Bulky cargo             | 1   | 5   | 3.95 $\pm$ 1.062 | 5                    |
| RB2     | Mobile using            | 1   | 5   | 3.91 $\pm$ 1.061 | 6                    |
| WE1     | Rainy weather           | 1   | 5   | 3.90 $\pm$ 1.159 | 7                    |
| WE2     | Hot weather             | 1   | 5   | 3.85 $\pm$ 1.070 | 7                    |
| TC2     | Lane re-arrangement     | 1   | 5   | 3.79 $\pm$ 1.062 | 9                    |
| IF3     | Poor road lighting      | 1   | 5   | 3.73 $\pm$ 1.081 | 10                   |
| RB3     | Ignoring road sign      | 1   | 5   | 3.71 $\pm$ 1.129 | 11                   |
| IF1     | Bumpy road              | 1   | 5   | 3.70 $\pm$ 1.088 | 12                   |

Table 6. Ranking the impact severity of transport risks.

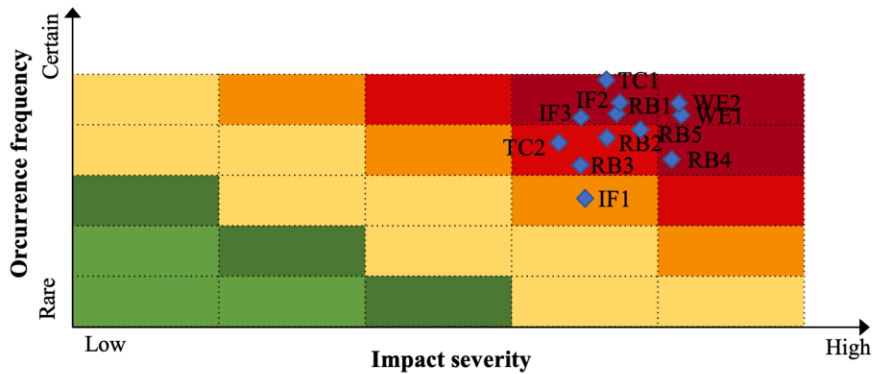


Figure 1: Matrix of traffic risks from cargo motorcycle rider’s perception

The cargo motorcycle riders work dependently on motorcycle riding; therefore, congestion flow combined with carrying bulky cargo bothers most cargo delivery motorcycle riders and poses significant potential traffic risks to them, even though many traffic management strategies have been applied in big cities in Vietnam (Truong et al., 2021). These findings are in contrast with previous research, which investigated the risky behaviour of app-based motorcycle taxi drivers (Nguyen-Phuoc et al., 2020). Compared with passenger motorcycle riders, whose mobile use and neglecting signal are seen as the most dangerous behaviour affecting travel crashes, cargo motorcycle drivers daily faced with external risks of congestion and heavy cargo (Lin and Kraus, 2009). Driving with large parcel boxes behind them, most of the respondents admitted that they ride motorcycles with high concentration and carefulness to minimize the risk of crashes and avoid cargo damage.

However, due to the huge requirements of delivering goods on schedule, many respondents have dangerous driving behaviour as using mobile and passing the red light which were perceived as high severity levels when occurred. Mobile use is perceived as a significant traffic risk since it impacts the driving concentration and safety driving of respondents. Furthermore, riding with excessive speed and ignoring road signs are ranked as the sixth and the eleventh potential risks relating to travel crashes by cargo motorcycle drivers. These results are similar to many previous studies conducted in Asian cities such as Vietnam (Quy Nguyen-Phuoc et al., 2023; Truong et al., 2020), Indonesia (Susilo et al., 2015), Taiwan (Chen, 2009), and Thailand (Arreeras et al., 2022). This implied that the awareness of respondents on traffic legal and regulation is still low. Respondents were concerned about the damaged goods that they have to pay a fine; however, risky driving behaviour is perceived by many respondents due to the pressure of on-time delivery and huge order requirements.

**Reveals from respondent characteristics and risk perception**

Respondents were classified by age, shipping experience, monthly income, weekly delivery trips, and daily working hours which individual characteristics significantly impact crashes and traffic risk perception. Gender was not included in the analysis due to the substantial gender disparity (there were only 12 female drivers).

In terms of age, there was a statistically significant difference between groups RB1 (Excessive speed), RB5 (Bulky cargo), and TC1 (Traffic congestion). Respondents aged between 26 and 35 were found to be a higher risky group of delivery jobs. These respondents are at the beginning of their family life and are thereby having more financial pressure. They often take on more orders, so they need to travel longer distances and work more hours to deliver. As a result, these motorcycle delivery riders often take higher traffic risks. Respondents aged over 45 years old had the lowest score which implied that the older the cargo riders, the less risk-taker behaviour they have for their work-riding. This result is similar to studies conducted in Thailand (Arreeras et al., 2022) and Taiwan (Chen, 2009).

Regarding monthly income, there were two traffic risks with statistically significant results: RB1 (excessive speed) and RB5 (bulky cargo). Respondents with a lower income perceive excessive speed and riding with bulky cargo with the highest score. These results implied that the cargo riders who have higher financial pressure might take more delivery orders, ride a longer distance and tend to

exceed the speed to reduce travel time, which is consistent with studies in Indonesia (Susilo et al., 2015) and Taiwan (Chen, 2009).

Regarding weekly delivery trips, six traffic risks were statistically significant, including RB1 (Excessive speed), RB2 (Mobile use), TC1 (Traffic congestion), IF3 (Poor road lighting), WE1 (Rainy weather), and WE2 (Hot weather). Respondents who have more trips to deliver cargo thought that RB1 (Excessive speed), RB2 (Mobile using), and TC1 (Traffic congestion) significantly impacted the possible crashes during their riding and, hence, were impeditive in the ability to complete their daily workload.

### **Conclusion**

The number of cargo motorcycle drivers increases significantly during and after the COVID-19 pandemic due to the huge shipping demand and the rapid development of e-commerce in Vietnam. Therefore, the delivery trips contribute strongly to the traffic congestion and traffic safety in cities. Both internal and external risks affect the road crashes of shipping drivers. The study found that traffic flow, infrastructure conditions, environmental issues, and risky driving behaviours contribute to the possible accidents from cargo motorcycle rider's perceptions. The results of the current study have various practical applications. First, safety measures should be conducted continuously from shipping service companies and transport authorities to cargo motorcycle drivers. Second, safety training and working-time limitations for cargo riders should be implemented more frequently. In addition, the improvement of road infrastructure and traffic signals should be strongly enhanced.

Although this study has shed light on how cargo motorcycle drivers perceive both internal and external risks, some limitations must be considered. First, the survey information was collected from a Hanoi, Vietnam, metropolitan agglomeration, whose features may differ significantly from those of other contexts. As a result, other investigations for different locations and nations would be required to compare with the findings of this study. Second, many of our participants were junior cargo drivers. It is hard to know if this is typical of crowd logistics adoption, though it appears to be the case; obviously, further research is needed.

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