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**Impact of Pedestrian Non-Compliance on Vehicular Headways at Signalized
Intersection in Kathmandu: A Case Study of Maharajgunj Intersection**

by

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A THESIS

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DEGREE OF MASTER OF SCIENCE IN TRANSPORTATION ENGINEERING**

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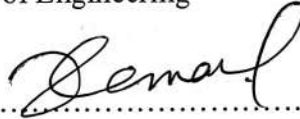


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The undersigned certify that they have read and recommended to Institute of Engineering for acceptance, a thesis entitled **“Impact of Pedestrian Non-Compliance on Vehicular Headways at Signalized Intersection in Kathmandu: A Case Study of Maharajgunj Intersection”** submitted by Santosh Dahal in partial fulfillment of the requirement for degree of Master of Science in Transportation Engineering.



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ABSTRACT

Signalized intersections in Kathmandu operate under heterogeneous traffic conditions dominated by two-wheelers, weak lane discipline, and complex vehicle-pedestrian interactions. While pedestrian non-compliance is well documented in Nepal, its operational impact on vehicular traffic remains unquantified. This study quantifies the effect of pedestrian non-compliance on vehicular headways at signalized intersection in Kathmandu. Data were collected using video-graphic methods at the Maharajgunj Intersection, yielding 407 observations. Vehicular headway was defined as the average time taken by the first 12 vehicles to pass the stop line during queue discharge. Pedestrian non-compliance was measured as violations during the pedestrian red phase. An independent samples t-test and multiple linear regression with log-transformed headway were employed. The t-test revealed significantly longer headways during non-compliance phases ($p < 0.001$). Regression results ($R^2 = 0.84$) showed that each additional non-compliant pedestrian increases headway by approximately 5.97% ($B = 0.058, p < 0.001$). Two-wheeler proportion reduced headway ($B = -1.181, p < 0.001$), while heavy vehicle proportion ($B = 0.941, p < 0.001$) and right-turn movements ($B = 0.364, p < 0.001$) increased headway. The effect was slightly more on approach operating under shared phase (6.28%) than those with separate phases (5.65%). Model diagnostics confirmed no multicollinearity, acceptable autocorrelation, and strong predictive validity. Pedestrian non-compliance significantly disrupts vehicular discharge at signalized intersections under mixed traffic conditions. The study recommends stricter enforcement of pedestrian signal, optimized signal timing, and improved geometric design to mitigate these impacts.

Keywords: Pedestrian non-compliance, vehicular headway, mixed traffic, signalized intersection, multiple linear regression, Kathmandu

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CCTV	Closed-Circuit Television
CI	Confidence Interval
CS	Conflicting Speed
DF	Degrees of Freedom
HCM	Highway Capacity Manual
MLR	Multiple Linear Regression
NC	Pedestrian Non-compliance
OLS	Ordinary Least Squares
PCU	Passenger Car Unit
Q-Q plot	Quantile-Quantile plot
RMSE	Root Mean Square Error
R ²	R-squared (Coefficient of Determination)
Sig.	Significance Level
SPSS	Statistical Package for the Social Sciences
TRB	Transportation Research Board
VIF	Variance Inflation Factor
LV	Light Vehicle Proportion

CHAPTER 1: INTRODUCTION

1.1 Background

Signalized intersections are critical components of urban traffic networks, serving as nodes where conflicting traffic streams are systematically organized to ensure safe and efficient movement. The operational efficiency of these intersections largely depends on queue dissipation processes, which can be effectively quantified through vehicular headways. Vehicular headway, defined as the time interval between two successive vehicles passing a reference point, plays a fundamental role in characterizing traffic flow and intersection performance. Classical traffic flow theory assumes that under stable operating conditions, vehicles discharge in a relatively consistent pattern during the green phase, allowing reliable estimation of saturation flow rates and capacity parameters. These principles are widely documented in the Highway Capacity Manual developed by the Transportation Research Board (2010). However, the assumptions underlying these classical models are primarily based on traffic environments characterized by strict lane discipline and relatively homogeneous vehicle composition, conditions typically observed in developed countries. In contrast, signalized intersections in many South Asian cities, including Kathmandu, operate under mixed and weakly lane-disciplined traffic conditions where heterogeneous vehicle types interact in complex ways. The traffic stream in Kathmandu is dominated by motorcycles and other two-wheelers, which exhibit highly flexible maneuvering behavior and can occupy smaller gaps within the traffic stream. Neupane (2020) reported that two-wheelers constitute a substantial proportion of vehicles at Kathmandu intersections and demonstrated that an increase in the proportion of two-wheelers leads to reduced vehicular headways and consequently higher saturation flow rates. These findings indicate that traffic flow characteristics in Kathmandu differ significantly from those assumed in Western-derived traffic models, highlighting the importance of context-specific operational analysis. Pedestrian activity introduces an additional layer of complexity to signalized intersection operations in Kathmandu, where non-compliant crossing behavior is highly prevalent. Pedestrian non-compliance is defined as pedestrians crossing during the pedestrian red phase (i.e., the vehicular green phase), thereby violating signal indications and potentially disrupting vehicular flow at the intersection. Shah and Pradhananga (2024) reported that a

significant proportion of pedestrians at signalized intersections in Kathmandu violate pedestrian signal indications, with many initiating crossing shortly after arrival. Their study also highlighted that factors such as waiting time and social influence from other violators affect violation behavior. Such non-compliance disrupts the intended separation of pedestrian and vehicular movements at signalized intersections. When pedestrians cross during the vehicular green phase, drivers are often required to slow down, yield, or alter their trajectory to avoid potential conflicts. These behavioral responses may interrupt the discharge pattern of vehicle platoons and increase variability in the time intervals between successive vehicles. As a result, pedestrian intrusions can influence vehicular headways and potentially reduce the efficiency of queue dissipation during the green phase. In traffic flow theory, even small disturbances in the discharge process can propagate through the vehicle stream, altering headway distribution and affecting overall intersection capacity.

Efforts to improve pedestrian compliance through technological interventions have produced only limited improvements in Kathmandu. Shah and Shahi (2023) evaluated the impact of pedestrian countdown signals at selected intersections and found that their installation resulted in only a 9.5 percent increase in compliance rates. This relatively modest improvement suggests that infrastructural and technological measures alone may be insufficient to substantially modify entrenched pedestrian crossing behavior.

The operational impacts of pedestrian interference on vehicular traffic have been documented in international research. Chen et al. (2016) developed a model for capacity considering pedestrian interference at signalized intersections, finding that pedestrian presence could reduce vehicular capacity by up to 14 percent in worst-case scenarios. Similarly, Rabbi et al. (2025) examined pedestrian non-compliance at signalized intersections in Dhaka, Bangladesh, and found that illegal pedestrian crossings during the vehicular green phase significantly increase vehicular headways, with each additional violation increasing headway by approximately 2.7 percent.

Despite this international evidence and the documented prevalence of pedestrian violations in Kathmandu, the operational consequences of pedestrian non-compliance on vehicular traffic flow in Nepal's capital remain insufficiently understood. In particular, there is a lack of empirical research quantifying how pedestrian non-compliance affects vehicular headway patterns at signalized intersections under such conditions. Understanding this relationship is important for improving the accuracy of intersection performance analysis, refining saturation flow estimation, and informing signal design and pedestrian management strategies in urban areas.

Given Kathmandu's distinctive traffic environment and the persistence of pedestrian non-compliance despite intervention efforts, a comprehensive analysis that explicitly incorporates pedestrian non-compliance as a key explanatory variable is necessary to better understand intersection performance. Therefore, this study aims to quantify the impact of pedestrian non-compliance on vehicular headways at signalized intersection in Kathmandu.

1.2 Statement of the Problem

Signalized intersections in Kathmandu operate under highly heterogeneous traffic conditions characterized by two-wheeler dominance, weak lane discipline, and complex vehicle-pedestrian interactions. Previous research has extensively documented the prevalence of pedestrian non-compliance at these intersections. Shah and Pradhananga (2024) found that 35% of pedestrians violate red signals immediately and nearly half do so within 7 seconds of arrival, but the operational consequences of such behavior remain unquantified. Shah and Shahi (2023) further demonstrated that even technological interventions like countdown signals achieve only marginal compliance improvements (9.5%), confirming that violations persist as a chronic feature of Kathmandu's intersection operations. Despite this well-documented behavioral reality, no empirical study in Nepal has quantified how pedestrian non-compliance affects vehicular headways at signalized intersections. The critical knowledge gap is not whether violations occur, as this is already established, but rather their operational impact on intersection performance. Specific unanswered questions include:

- Does pedestrian non-compliance significantly affect vehicular headways?
- What is the magnitude and direction of the impact of pedestrian non-compliance on vehicular headways?
- Does effect of pedestrian non-compliance on vehicular headways differ between approaches operating under shared single phase and those with separate phases for through and right turning movements?

Consequently, traffic engineers in Kathmandu lack empirical evidence to understand how pedestrian violations affect vehicular headways at signalized intersections. This study addresses this gap by developing a model to quantify the impact of pedestrian non-compliance on vehicular headways at a signalized intersection. The findings provide a foundation for future research on capacity estimation and signal timing adjustments.

1.3 Research Objectives

The main objective of this research is to quantify the impact of pedestrian non-compliance behavior on vehicular headways at a signalized intersection in Kathmandu. The specific objectives of this study are:

- a. To model the impact of pedestrian non-compliance on vehicular headways under heterogeneous traffic condition at signalized intersection in Kathmandu.
- b. To compare the effect of pedestrian non-compliance on vehicular headways between approaches operating under shared signal phases and those with separate phases for through and right-turn movements.

1.4 Scope of the Study

The scope of this study is as follows:

- Focused on one signalized intersection in Kathmandu Valley.
- Examined vehicular headways during queue discharge at the signalized intersection.
- Investigated pedestrian non-compliance behavior at the crosswalk and its impact on vehicular headways.
- Considered vehicle composition including two-wheelers, cars, light vehicles, and heavy vehicles.
- Data collected during daytime over multiple days.
- Video-graphic method used to record both pedestrian behavior and vehicle movements.

1.5 Limitations of the Study

The limitations of this study are as follows:

- This study examined only one intersection in Kathmandu Valley.
- Frequent signal outages during the collection period reduced the usable data.
- Unobserved factors such as driver behavior and pedestrian characteristics were not controlled for in the analysis.
- Traffic volume was statistically insignificant in this study, likely due to its limited variability at the study site; however, this result is context-specific and should not

- be generalized to intersections with wider volume fluctuations.
- This study covers through movements and right-turning movements only, as left-turning movement operates without signal control and do not form queues at the intersection.
 - This study covers only three approaches of intersection only, as Teaching approach did not have functioning pedestrian signal.
 - Effect of Pedestrian Non-compliance was considered only for first twelve vehicles.

1.6 Organization of the Thesis

This thesis is organized into five chapters, following the standard structure for master's research at the Institute of Engineering, Tribhuvan University.

Chapter 1: Introduction presents the background, problem statement, research objectives, scope and limitations, and organization of the thesis.

Chapter 2: Literature Review provides a comprehensive review of relevant research globally and in the Nepali context. It covers pedestrian non-compliance behavior, vehicular headway concepts and determinants, vehicle-pedestrian interactions, multiple linear regression applications in traffic engineering, and identifies the research gap addressed by this study.

Chapter 3: Research Methodology describes the study area, data collection procedures, variable definition and measurement, analytical framework, and model validation approaches.

Chapter 4: Results and Discussion presents descriptive statistics, correlation analysis, multiple linear regression results, interpretation of findings and model validation results.

Chapter 5: Conclusion and Recommendation summarizes key findings, draws conclusions in relation to research objectives, and provides recommendations for policy, practice, and future research.

The thesis concludes with references and appendices containing data collection sheets, raw data samples and detailed regression output.

CHAPTER 2: LITERATURE REVIEW

2.1 Pedestrian Non-compliance

2.1.1 Global Perspectives

International research on pedestrian red-light violations has widely identified waiting time as a key determinant of non-compliance. Brosseau et al. (2013) found that longer waiting times significantly increase the likelihood of violations, alongside other influencing factors such as group size and traffic gap availability. Guo et al. (2011) further demonstrated that violation behavior follows a hazard-based pattern, where the probability of crossing increases as waiting time elapses. Social conformity effects are also well documented; Rosenbloom (2009) noted that pedestrians are more likely to violate when observing others doing so.

2.1.2 South Asian Context

Research from India highlights several factors influencing pedestrian behavior under mixed traffic conditions. Mukherjee and Mitra (2020) investigated pedestrian signal violation behavior at signalized intersections in Kolkata and found that violation is significantly associated with variables such as traffic characteristics, pedestrian attributes, and roadway conditions. Their analysis showed that pedestrian crossing decisions are influenced by surrounding traffic flow and individual characteristics, reflecting the complexity of behavior under heterogeneous traffic conditions. Kumar and Ghosh (2020) analyzed pedestrian-vehicle conflicts at signalized intersections using statistical modeling approaches, including binary logit models. Their study identified factors such as vehicle type, pedestrian non-compliance, and group size as significant variables affecting the occurrence and nature of pedestrian-vehicle interactions. Using a hazard-based duration modeling framework, Dhoke et al. (2021) analyzed pedestrian waiting time and crossing decisions at signalized intersections in Nagpur, India. The study demonstrated that pedestrian waiting time and response behavior can be effectively modeled using statistical distributions such as Weibull and log-logistic, and that these factors significantly influence the likelihood of crossing during different signal phases. Most relevantly, Raoniar et al. (2022) applied a hazard-based duration approach to examine pedestrian crossing behavior at signalized intersections in

Kolkata. Their study reported that a substantial proportion of pedestrians initiate crossing shortly after arriving at the curb during the red phase, and identified factors such as glance behavior, distraction, and traffic volume as significant predictors of pedestrian crossing decisions.

2.1.3 Kathmandu-Specific Research

Several studies have examined pedestrian behavior and safety at Kathmandu's intersections, providing context for the present research. Shah and Pradhananga (2024) conducted the most comprehensive assessment of pedestrian red-light violation in Kathmandu, analyzing 1,790 pedestrian observations. Their study identified waiting time as the primary determinant of violation behavior, with red phases exceeding 100 seconds triggering near-instant violation upon arrival. Approximately 35% of pedestrians violate signals immediately, and nearly 50% violate within the first 7 seconds of arrival. This extremely low waiting tolerance has profound implications for intersection operations, as pedestrian violations coincide precisely with the period when vehicles begin queue discharge. Other significant factors included a social conformity effect, perceived traffic volume, crossing length, and remaining red duration, where less than 50 seconds remaining encouraged compliance while more than 100 seconds encouraged violation. Shahi and Gautam (2020) documented widespread mid-block crossings in Kathmandu, finding that approximately 23% of pedestrian fatalities occur in non-compliance scenarios. Delays exceeding 20 seconds trigger unsafe crossing decisions, and physical barriers significantly reduced violations. Shah and Shahi (2023) evaluated countdown pedestrian signals, finding only 9.5% compliance improvement, confirming that technological interventions alone are insufficient and that high violation levels persist.

2.2 Vehicular Headway: Concepts and Determinants

2.2.1 Definition and Measurement

Headway, defined as the time interval between successive vehicles passing a reference point, is fundamental to traffic flow theory. Saturation headway, the average headway achieved during stable flow conditions, forms the basis for capacity analysis in the Highway Capacity Manual (Transportation Research Board, 2010). Traditional measurement practice typically begins from the fifth vehicle in queue to exclude start up lost time associated with the first four vehicles. For lane groups with multiple lanes, the HCM specifies that average headway

per lane should be used when comparing with single lane groups to ensure that lane configuration does not bias comparisons between multi-lane through movements and single lane turning movements (Transportation Research Board, 2010). However, the applicability of these conventional measurement practices has been challenged in mixed traffic contexts, particularly in South Asian cities where heterogeneous vehicle types, weak lane discipline, and non-compliance behaviors are prevalent. Mondal and Gupta (2019) analyzed vehicle headway during queue dissipation at signal controlled intersections under heterogeneous traffic conditions in India. Their findings indicated that headway distributions in mixed traffic often follow log normal patterns, reflecting behavioral variability rather than classical lane based assumptions.

Rabbi et al. (2025) examined the impact of pedestrian and motorbike non-compliance on traffic flow at signalized intersections in Dhaka, Bangladesh. In their methodology, the measurement window for illegal pedestrians was defined as the time required for the first twelve vehicles to pass the stop line during the green phase. Accordingly, the observed average headway was calculated using the time headways of these first twelve discharged vehicles. In comparison with the conventional saturation headway approach, which excludes the initial vehicles to account for start-up lost time, the observed average headway model demonstrated superior performance, yielding a higher adjusted R^2 value. Moreover, variables representing motorbike non-compliance, specifically motorbikes obstructing the lead vehicle and the percentage of motorbikes in the traffic stream, were found to be statistically significant only in the observed average headway model. Based on these findings, the study concluded that including the initial vehicles in headway estimation is essential for capturing the effects of non-compliance behavior under heterogeneous traffic conditions.

Based on these precedents, the present study adopts the observed average headway approach, measuring average observed headway from the first twelve vehicles in the discharging queue. This approach is considered more suitable for the Kathmandu context, where pedestrian non-compliance and two-wheeler dominance may affect queue discharge from the very beginning of the green phase.

2.2.2 Factors Affecting Headway

Vehicle Composition: Heavy vehicles increase headway due to slower acceleration and driver caution. Conversely, two-wheelers decrease average headway by filtering through gaps and maintaining shorter following distances (Neupane, 2020). Wani et al. (2019) also

identified vehicle type as a significant factor affecting discharge headway under heterogeneous traffic conditions.

Traffic Volume: A fundamental negative relationship exists between volume and headway: as volume increases, vehicles follow more closely (Transportation Research Board, 2010).

Geometric Conditions: Lane width, grade, and turning radius influence headway through effects on maneuverability. Turning movements experience larger headways due to geometric constraints.

2.3 Pedestrian-Vehicle Interactions: Safety and Operational Perspectives

Research on pedestrian-vehicle interactions has primarily focused on safety assessment using surrogate safety measures. Post-Encroachment Time (PET), defined as the time difference between a vehicle departing and a pedestrian arriving at a conflict point, is widely used to quantify the severity of interactions, with smaller values indicating more critical conflicts (Gettman & Head, 2003). Kumar et al. (2022) applied the Swedish Traffic Conflict Technique to evaluate pedestrian-vehicle conflicts at signalized intersections in India, using indicators such as Time to Accident (TA) and Conflicting Speed (CS) to classify conflict severity levels. Kumar and Ghosh (2020) analyzed pedestrian-vehicle interactions at signalized intersections and reported variations in driver yielding behavior under mixed traffic conditions. Kumar et al. (2019) examined conflicts between pedestrians and right-turning vehicles and reported that turning movements influence the occurrence of pedestrian-vehicle conflicts. Chaudhari et al. (2021) evaluated pedestrian safety at crosswalks under mixed traffic conditions and reported that PET can be used as an indicator of interaction severity. Friedrich and Barthauer (2019) used microscopic simulation models calibrated with traffic and conflict data to assess intersection performance in terms of traffic efficiency and safety.

In comparison to safety-focused studies, fewer studies have examined the operational effects of pedestrian-vehicle interactions. Chen et al. (2016) developed a capacity estimation model for signalized intersections that incorporates pedestrian interference and reported that pedestrian presence affects vehicular capacity. Their analysis also considered headway variation during the transition from start-up conditions to stable flow. More recently, Rabbi et al. (2025) analyzed the effects of pedestrian and motorbike non-compliance at signalized intersections under mixed traffic conditions. Their study reported that pedestrian non-compliance has significant positive effect on vehicular headway.

2.4 Multiple Linear Regression in Traffic Engineering

2.4.1 Application in Headway Analysis

Multiple linear regression (MLR) enables the simultaneous examination of multiple factors affecting a dependent variable while controlling for confounding influences. Neupane (2020) utilized MLR to estimate Motorcycle Equivalent Units at Kathmandu intersections, demonstrating its applicability in local traffic conditions. Similarly, Rabbi et al. (2025) applied MLR with log-transformed headway in Dhaka and found that illegal pedestrian crossings significantly increased headway. Kumar and Ghosh (2020) employed both multiple linear regression and binary logit models to analyze pedestrian–vehicle conflicts and yielding behavior. Further supporting the applicability of MLR, Mondal and Gupta (2019) applied a multilinear regression model to examine discharge headway at signalized intersections under mixed traffic conditions. Collectively, these studies establish MLR as a suitable and effective methodology for headway analysis in mixed-traffic conditions.

2.4.2 Model Assumptions and Validation

Valid MLR application requires satisfying assumptions of linearity, independence of residuals, homoscedasticity, and approximate normality (Tabachnick & Fidell, 2013). Diagnostic procedures include:

Assumption	Diagnostic Method	Acceptance Criteria
Linearity	Residuals vs. fitted values plot	Random scatter
Independence	Durbin-Watson statistic	$1.5 < DW < 2.5$
Homoscedasticity	Residuals vs. fitted values plot	Constant spread
Normality	Q-Q plot	Points follow diagonal line
No perfect multicollinearity	Variance Inflation Factor (VIF)	$VIF < 5$

VIF analysis assesses multicollinearity among predictors. Values exceeding 5 may indicate potential multicollinearity issues that can affect the stability of regression coefficients (Hair et al., 2010).

2.4.3 Log Transformation and Interpretation

The dependent variable was transformed using the natural logarithm to address the inherent positive skewness typically observed in vehicular headway. This logarithmic transformation

serves to normalize the distribution of residuals and stabilize variance, thereby mitigating potential heteroscedasticity distributions (Washington et al., 2020). Furthermore, this approach facilitates a more intuitive interpretation of the regression coefficients, which can be expressed as the approximate percentage change in headway associated with a marginal increase in the predictor variables.

2.5 Research Gap

Despite extensive documentation of pedestrian non-compliance at signalized intersections in Kathmandu (Shah and Pradhananga, 2024; Shah and Shahi, 2023), no empirical study has quantified its impact on vehicular headway. Therefore, this study addresses the gap by developing a multiple linear regression model to quantify the effect of pedestrian non-compliance on vehicular headway at a signalized intersection in Kathmandu, while controlling for traffic composition, movement type, and approach characteristics.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Framework

The methodological framework adopted in this study comprises five main phases, following established approaches in traffic engineering research. This structured approach ensures that each step, from initial planning to final interpretation, is logically connected and contributes to the robustness of the findings.

Phase 1: Literature Review

The study commenced with a comprehensive review of existing literature on traffic flow theory, pedestrian-vehicle interactions, and factors affecting headway at signalized intersections. This phase, detailed in Chapter 2, established the theoretical foundation, identified the research gap concerning pedestrian non-compliance in mixed traffic, and guided the selection of key variables.

Phase 2: Study Design and Data Collection

Based on the literature review, the research methodology was designed. This involved selecting a suitable study site in Kathmandu based on pre-defined criteria, establishing a video recording protocol, and defining the procedures for data extraction. Primary data was then collected through video recordings at the selected intersection.

Phase 3: Data Processing and Variable Extraction

Video recordings were analyzed frame-by-frame to extract relevant variables, including vehicular headway, traffic composition, volume, movement type, and pedestrian non-compliance. The extracted data were compiled into a structured dataset for analysis.

Phase 4: Statistical Modeling and Analysis

A two-stage analytical approach was adopted. First, an independent samples t-test was conducted to examine whether pedestrian non-compliance significantly affects vehicular headway. Second, correlation analysis was performed for variable screening, followed by development of a multiple linear regression model to quantify the impact while controlling for confounding variables.

Phase 5: Result and Discussion

The final phase involved interpreting the statistical results within the context of the research objectives and existing literature. The findings were synthesized to draw meaningful

conclusions about the impact of pedestrian non-compliance, discuss their implications for traffic engineering practice in Kathmandu, and provide recommendations for future research.

A visual representation of this framework is provided in Figure 3.1.

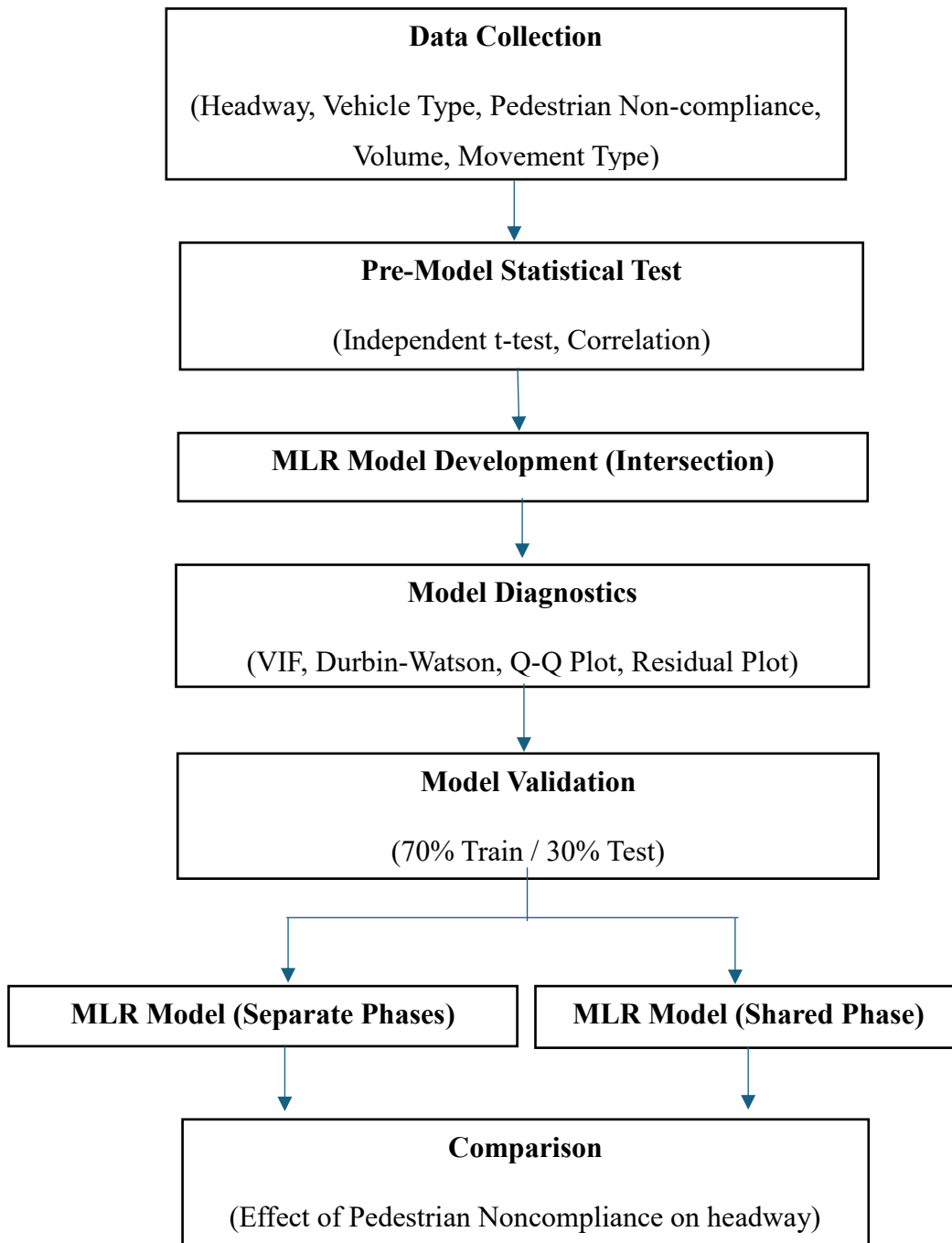


Figure 3.1: Methodological Framework Flowchart

3.2 Study Area Description

3.2.1 Site Selection Criteria

The study intersection was selected based on the following criteria:

The study intersection was selected based on five criteria to ensure validity and generalizability:

1. Representative Traffic Composition: The site exhibits Kathmandu's characteristic mixed traffic flow with significant two-wheeler presence.
2. Adequate Pedestrian Activity: Sufficient pedestrian volume to observe non-compliance events within reasonable periods.
3. Signalized Operation: Intersection controlled by traffic signals with clearly defined phases for vehicle and pedestrian movements.

3.2.2 Site Characteristic

The study was conducted at the Maharajgunj Intersection, a major urban junction located in Kathmandu, Nepal. The intersection is a four-legged signalized intersection comprising two types of approaches: two approaches with seven lanes each (four incoming and three outgoing) and two approaches with four lanes each (two incoming and two outgoing). For the approaches with seven lanes, the incoming section includes one free left-turn lane, two through lanes forming a through movement group, and one exclusive right-turn pocket lane. In contrast, the approaches with four lanes have one free left-turn lane and one shared lane accommodating both through and right-turning movements. The corresponding vehicular movement pattern of the intersection is illustrated in Figure 3.3.

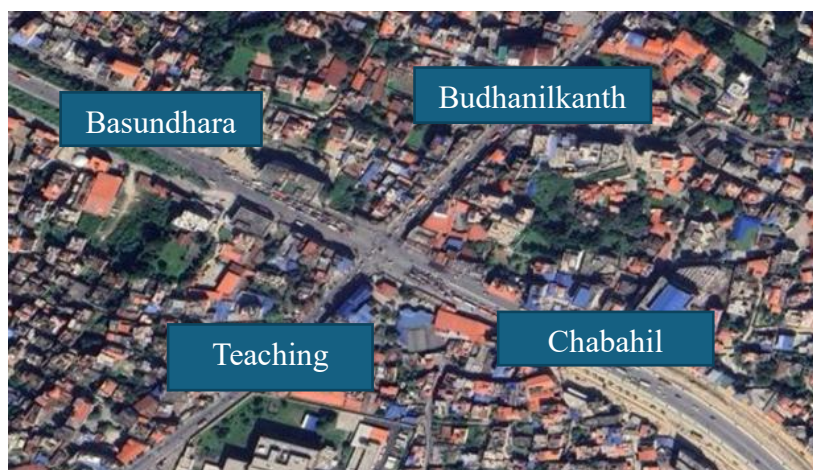


Figure 3.2: Maharajgunj Intersection, Kathmandu

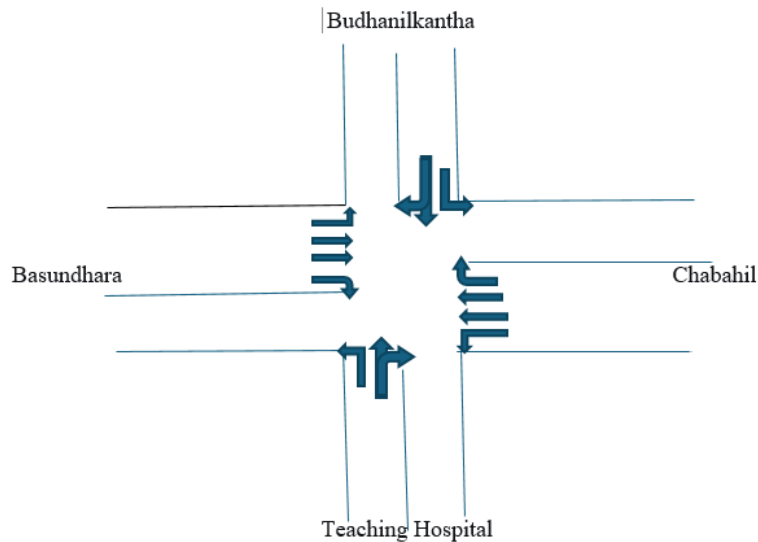


Figure 3.3: Vehicular Movement Pattern of Maharajgunj Intersection

The signalized intersection operates under a four-phase system with distinct movement patterns and timings. In Phase 1 (P1), through movements between Basundhara and Chabahil in both directions are permitted, with a green time of 83 seconds followed by an amber interval of 5 seconds. Phase 2 (P2) serves traffic from the Budhanilakantha approach, allowing through movement toward Teaching Hospital and right-turn movement toward Basundhara, operating with a green time of 85 seconds and an amber time of 5 seconds. In Phase 3 (P3), vehicles from the Teaching approach are accommodated, permitting through movement toward Budhanilakantha and right-turn movement toward Chabahil, with a green duration of 70 seconds followed by a 5-second amber interval. Phase 4 (P4) is dedicated exclusively to right-turn movements, allowing vehicles from Basundhara to turn toward Teaching Hospital and from Chabahil toward Budhanilakantha, operating with a shorter green time of 43 seconds and an amber interval of 5 seconds. The details of the four-phase signal operation is illustrated in Figure 3.4.

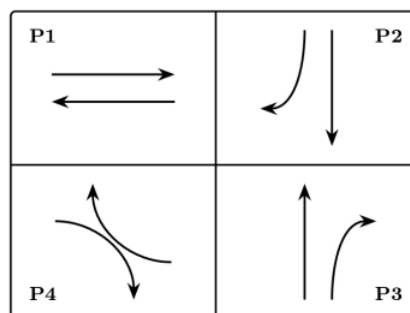


Figure 3.4: Existing four phase signal operation at Maharajgunj Intersection

The vehicular signal system is well coordinated with pedestrian signals at three approaches, namely Basundhara, Chabahil, and Budhanilakantha, while the Teaching approach does not have a functioning pedestrian signal and thus was not considered in this study. Pedestrian movements are integrated within the vehicular phases: at the Basundhara approach, the pedestrian green interval coincides with Phase 3 and is equal in duration to its green time; at the Chabahil approach, pedestrian green is provided during Phase 2; and at the Budhanilakantha approach, pedestrian crossing is permitted during Phase 1, with corresponding green times matching the respective vehicular phase durations.

3.3 Data Collection

Video recording was employed as the primary data collection method, following established practices in traffic engineering research. This approach offers several advantages including a permanent record allowing repeated viewing and verification, the ability to extract multiple variables from the same footage, minimal interference with natural behavior, and precise timing measurements for headway calculation. For this study, multiple CCTV cameras with timestamp display were used to capture three of the four approaches at the intersection. Teaching approach was excluded from data collection due to a malfunctioning pedestrian signal at the time of the study. All cameras were installed at elevated rooftop locations positioned to provide clear, unobstructed views of their respective approaches. Each camera was equipped with high-capacity memory cards for extended recording and connected to portable power supplies for continuous operation during data collection. Each camera was positioned to provide a clear, unobstructed view of the stop line, approach lanes, signal indications, pedestrian crossing area and sufficient upstream distance to observe vehicle queuing. The camera height and angle were optimized for accurate timing measurements and clear vehicle classification. Test recordings were conducted prior to formal data collection to verify field of view and image quality for all three camera positions. Data collection was carried out over multiple days in January 2026, covering the period from 9:00 AM to 6:00 PM each day. All observations were conducted under clear and dry weather conditions, ensuring consistency and minimizing the influence of environmental factors on traffic flow characteristics.

3.4 Data Sampling

The data sampling strategy was designed to capture representative traffic conditions at the study intersection. Observations were categorized based on approach type and movement type, and a sufficient number of observations were collected from each category during peak hours to ensure adequate representation of traffic conditions. A stratified approach was adopted to account for variability across different approaches and movements. This sampling framework ensures that the dataset adequately represents operational conditions for subsequent analysis.

3.5 Variable Definition and Measurement

3.5.1 Dependent Variable: Headway

Vehicular headway was defined as the observed average headway of first twelve vehicles during queue discharge. Headway was estimated using video-based observations by recording the total time required for the first 12 vehicles to pass a stop line immediately after the commencement of the green phase. Vehicular headway was computed by dividing the total discharge time by 11, thereby representing an aggregate measure of vehicle spacing during the initial discharge period.

The selection of the first 12 vehicles was guided by both literature and field observations. First, Rabbi et al. (2025) proposed observed average headway over the first 12 vehicles, arguing that excluding the first four vehicles omits critical non-compliance effects in mixed traffic. Second, informal field observations showed that right-turning queues consistently exceeded 12 vehicles but were not substantially longer. Therefore, selecting the first 12 vehicles ensured a consistent and adequate sample across all phases.

The study intersection exhibits heterogeneous lane configurations across movements. Through movements operate as a two-lane group in major approaches, while right-turn movements are served by a single dedicated lane. The minor approach has a single shared lane for both through and right-turning movements. For through movements, headway was measured separately for each lane within the lane group by recording the total discharge time for the first 12 vehicles in each lane. The lane-specific headway values were then averaged to obtain a representative headway for the through movement in each cycle. For right-turn movements, which operate as a single-lane stream, headway was directly computed from the total discharge time of the first 12 vehicles. For minor approach, where

through and right-turn movements shared a single lane and were released simultaneously during the same green phase, headway was measured for the combined traffic stream without distinguishing between movement types. This approach ensured consistency in measurement across different movement types under heterogeneous traffic conditions.

3.5.2 Independent Variables

To analyze the factors influencing vehicular headway, the independent variables were categorized into traffic characteristics, pedestrian behavior, and movement/approach attributes. All variables related to traffic composition and pedestrian behavior were measured within the same observation window used for headway, i.e., the discharge of the first 12 vehicles to ensure methodological consistency.

Traffic Volume (Volume): Traffic volume was defined as the number of passenger car units (PCU) per lane per signal phase passing through the intersection. Vehicle counts were converted into PCU using standard equivalency factors: 0.25 for two-wheelers, 1.0 for cars, 1.5 for light commercial vehicles, and 3.0 for heavy vehicles (Kathmandu Valley Intelligent Traffic System, 2022). For major approaches with through movement lane groups, the total number of vehicles of each category passing during the green phase was counted from video observations, converted into PCU, and the total PCU was divided by two to obtain per-lane volume for the two-lane group. For right-turn movements, the total number of vehicles of each category passing during the green phase was counted and converted into PCU for the single lane. For minor approaches with shared movement conditions, where through and right-turn movements operated within a single lane during the same green phase, the total number of vehicles was counted and converted into PCU without movement separation.

Traffic Composition: Traffic composition was represented as proportions of different vehicle categories within the traffic stream, each computed as the count of a specific vehicle type among the first 12 vehicles observed during queue discharge. All proportions range from 0 to 1.

Two Wheeler Proportion (TW): Two-wheeler proportion represents the proportion of motorcycles and scooters.

Car Proportion (Car): Car proportion represents the proportion of passenger cars.

Light Vehicle Proportion (LV): Light vehicle proportion represents the proportion of light commercial vehicles (e.g., microbus and light commercial vehicles).

Heavy Vehicle Proportion (HV): Heavy vehicle proportion represents the proportion of buses and trucks.

Pedestrian Non Compliance (NC): Pedestrian non-compliance was defined as the number of pedestrians crossing the roadway during the pedestrian red signal phase. It was measured from video recordings as the count of such violations occurring within each signal phase corresponding to the discharge period of the first 12 vehicles. For through movements operating as a two-lane group, pedestrian non-compliance was recorded separately for each lane and then averaged to obtain a representative value for the lane group. For single-lane movements, NC was directly counted within the same observation window.

Movement Type (Type): Movement types were represented using dummy variables to capture differences in operational characteristics of lanes. The three movement types are mutually exclusive, as each corresponds to a distinct lane configuration at the intersection.

- Right-Turn Movement (Right): Dummy variable (1 = right-turn movement from dedicated right-turn lane, 0 = otherwise)
- Through Movement (Through): Dummy variable (1 = through movement from dedicated through lane, 0 = otherwise)
- Shared Movement (Shared): Dummy variable (1 = shared movement from single lane serving both through and right-turn vehicles, 0 = otherwise)

Approach Type (Approach): Approach type is a categorical variable representing intersection approaches, classified based on signal phasing into shared-phase operations and separate-phase operations for through and right-turn movements. This classification captures variations in geometric and operational characteristics that may influence vehicular headway under heterogeneous traffic conditions.

3.6 Sample Size Determination

Sample size was determined based on established guidelines for multiple linear regression. Peduzzi et al. (1996) recommend a minimum of 10-15 observations per predictor variable to ensure stable coefficient estimation. With 10 predictor variables in the model, this corresponds to a minimum sample size of 100 to 150 observations. Green (1991) further suggests a minimum sample size of $(104 + m)$, which in this case equals 114 observations, while Tabachnick and Fidell (2013) recommend $(50 + 8m)$, resulting in a requirement of 130 observations for ten predictors. The final sample size of 407 observations substantially exceeds all recommended thresholds, thereby ensuring adequate statistical power and reliable estimation of model parameters.

3.7 Analytical Approach

3.7.1 Independent Samples t-Test

As an independent check of the relationship between pedestrian non-compliance and vehicular headway, an independent samples t-test was conducted to examine whether pedestrian non-compliance has a statistically significant effect on vehicular headway. For the purpose of analysis, observations were categorized into two groups: Group 1 consisted of phases without pedestrian non-compliance events ($NC = 0$), defined as compliance phases, while Group 2 included phases with at least one pedestrian non-compliance event ($NC \geq 1$), defined as non-compliance phases. The null hypothesis (H_0) states that there is no statistically significant difference in mean vehicular headway between compliance and non-compliance phases, whereas the alternative hypothesis (H_1) states that a statistically significant difference exists between the two groups. The test was performed at a 95% confidence level ($\alpha = 0.05$), where a p-value less than 0.05 indicates rejection of the null hypothesis. The independent samples t-test assumes independence of observations, approximate normality of the dependent variable within groups, and homogeneity of variances. Given the large sample size ($N = 407$), the normality assumption is considered robust under the Central Limit Theorem. Homogeneity of variance was assessed using Levene's test as part of the statistical output. Although the t-test provides initial evidence of association, it does not control for other influencing factors; therefore, multiple linear regression was subsequently applied to isolate the independent effect of pedestrian non-compliance while accounting for traffic and geometric variables.

3.7.2 Correlation Analysis

Following the t-test, Pearson correlation coefficients were calculated among the independent variables to examine interrelationships and assess potential multicollinearity prior to regression modeling. Correlation analysis was used as an initial screening tool, and pairs of variables exhibiting correlation coefficients greater than 0.7 (in absolute value) were considered indicative of potential multicollinearity. Based on the correlation results, variables exhibiting high correlation were carefully evaluated to avoid redundancy in the regression model. Traffic volume (Volume) was excluded due to its strong correlation with movement-related variables. Car proportion (Car) was removed as it showed high negative correlation with two-wheeler proportion (TW) and was treated as the reference category within the traffic composition group. Similarly, through movement (Through) was used as

the reference category among movement-type dummy variables to avoid the dummy variable trap. The approach type (Approach) variable was excluded from the model due to its perfect correlation with the shared movement variable, indicating redundancy.

3.7.3 Multiple Linear Regression

A multiple linear regression model was developed to quantify the relationship between headway and the identified independent variables. Headway data were transformed using the natural logarithm to address skewness and satisfy the normality assumption of linear regression (Mondal and Gupta, 2019). The general form of the model is:

$$\ln(h) = \beta_0 + \beta_1(TW) + \beta_2(LV) + \beta_3(HV) + \beta_4(NC) + \beta_5(Shared) + \beta_6(Right) + \dots + \varepsilon \quad (1)$$

Where $\ln(h)$ is the natural logarithm of headway in seconds, β_0 represents the intercept, $\beta_1, \beta_2, \dots, \beta_6$ are coefficients for each predictor variable, and ε denotes the error term.

Reference categories:

- Through movement (Through) served as the reference category for movement type.
- Car proportion (Car) served as the reference category among vehicle composition variables.

Therefore, only NC, Right and Shared (movement type) and TW, LV, and HV (vehicle composition) were entered into the regression model.

Model parameters were estimated using ordinary least squares regression in SPSS statistical software. Statistical significance was assessed at a 95% confidence level, with p-values below 0.05 considered as significant reflecting the exploratory nature of certain variables.

Model fit was evaluated using multiple criteria. The coefficient of determination (R^2) indicates the proportion of variance in headway explained by the predictors. The adjusted R^2 accounts for the number of variables included, penalizing the addition of unnecessary predictors. The F-statistic tests whether the overall model provides a significantly better fit than a null model (intercept-only model with no predictors). This modeling approach allows for simultaneous examination of multiple factors affecting headway while controlling for confounding variables, providing a robust framework for understanding traffic operations at the study intersection.

3.7.4 Model Diagnostics and Validation

Multiple diagnostic techniques were employed to ensure the reliability and generalizability of the regression model. These techniques addressed potential issues including multicollinearity, autocorrelation, influential observations, and predictive performance on

unseen data. Multi collinearity among predictor variables was assessed using Variance Inflation Factors. For each predictor, VIF was calculated as the reciprocal of one minus the R^2 value obtained from regressing that predictor against all other predictors in the model. Values below 5 were considered indicative of acceptable multi collinearity, while values exceeding 5 would indicate potentially problematic multi collinearity warranting remedial action such as variable removal or combination.

The presence of autocorrelation in residuals was examined using the Durbin-Watson statistic. This test identifies whether adjacent residuals are correlated, which would violate the independence assumption of ordinary least squares regression. Values falling between 1.5 and 2.5 were interpreted as indicating no significant autocorrelation, while values outside this range would suggest the need for further investigation or alternative modeling approaches. The normality of residuals was assessed using Quantile-Quantile (Q-Q) plots of unstandardized residuals. A close alignment of points along the diagonal line was interpreted as evidence of approximate normal distribution. Homoscedasticity was evaluated using scatter plots of standardized residuals versus predicted values. A random dispersion of points without a clear pattern was considered indicative of constant variance. The assumption of a linear relationship between the independent variables and the dependent variable, was verified using partial regression plots. Cook's Distance was calculated to identify influential observations that disproportionately affect parameter estimates (Cook, 1977). This measure combines information on both residual size and leverage to quantify each observation's impact on the model. Values exceeding 1.0 were considered potentially influential and would trigger closer examination to determine whether data entry errors or unique conditions warranted exclusion or separate analysis.

Holdout validation was performed to assess the model's predictive performance on data not used in estimation. The full dataset of observations was randomly divided into a training set comprising 70 percent of observations for model estimation and a validation set comprising the remaining 30 percent for testing. The model was estimated using only the training data, after which predictions were generated for the validation set. Predictive accuracy was evaluated by comparing R^2 values between training and validation sets, calculating Root Mean Square Error for the validation predictions. Close agreement between training and validation performance would indicate that the model generalizes well to new data and is not over fitted to peculiarities of the estimation sample.

3.7.5 Comparison of Pedestrian Non-compliance Effect on Vehicular Headway under Shared and Separate Signal Phases

To compare the effect of pedestrian non-compliance on vehicular headways between approaches operating under shared phases and those with separate phases for through and right-turning movements, two multiple linear regression models were developed. In both models, the natural logarithm of vehicular headway ($\ln h$) was used as the dependent variable. For approaches operating under separate phases, the independent variables included pedestrian non-compliance (NC), movement type (Type), proportion of two-wheelers (TW), cars (Car), light vehicles (LV), heavy vehicles (HV), and traffic volume. The variable, Type was treated as a categorical variable, where 0 represents through movement and 1 represents right-turning movement; thus, through movement was considered the reference category. For approaches operating under a shared phase, six independent variables were included: NC, TW, Car, LV, HV, and Volume. The movement type variable was excluded from this model, as both movements operate simultaneously under shared phasing. Prior to model development, a correlation analysis was conducted to examine relationships among the independent variables and to assess potential multicollinearity. Variables exhibiting high correlation were carefully evaluated to avoid redundancy in the regression models. Finally, the effect of pedestrian non-compliance on vehicular headway was compared between the two types of signal phasing based on the estimated regression coefficients.

3.7.6 Software Used

All statistical analyses were conducted using IBM SPSS Statistics (Version 27). SPSS was selected for its comprehensive regression diagnostics, automated calculation of VIF and influence statistics, and professional output formatting suitable for thesis presentation.

3.8 Ethical Considerations

This study involved observation of public behavior in a natural setting without intervention or manipulation. No personally identifiable information was collected about drivers or pedestrians. Video recordings were used solely for data extraction and were not shared or distributed.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Descriptive statistics were computed to summarize the central tendency and dispersion of the study variables, providing an overview of traffic composition, pedestrian behavior, and vehicular headway characteristics within the dataset. Descriptive statistics were computed for all continuous and categorical variables included in the analysis. The final sample comprised 407 observations. Of these, 211 observations involved no pedestrian non-compliance, and 196 observations involved at least one non-compliant pedestrian action.

4.1.1 Continuous Variables

The descriptive statistics (minimum, maximum, mean, and standard deviation) for all continuous variables included in the analysis, namely Headway, pedestrian non-compliance (NC), two-wheeler proportion (TW), car proportion (Car), light vehicle proportion (LV), heavy vehicle proportion (HV), and traffic volume were computed. The results are presented in Table 4.1. The dependent variable, vehicular headway, recorded a mean value of 1.133 seconds ($SD = 0.46$), with observed values ranging from 0.636 to 3.636 seconds, indicating moderate dispersion in inter-vehicular spacing under prevailing traffic conditions. The primary explanatory variable, pedestrian non-compliance (NC), exhibited a mean of 1.118 ($SD = 1.621$), with a range of 0 to 9 events, reflecting intermittent and spatially varying pedestrian violation activity across signal phases. Among the control variables, traffic volume showed the greatest variability (Mean = 42.89, $SD = 21.13$), indicating difference in traffic demand across phases. Right turning phases in major roads had relatively low volume compared to through and shared phases. Vehicle composition variables, derived from the first 12 vehicles observed during the queue dissipation phase of each signal cycle, indicate a pronounced dominance of two-wheelers in the traffic stream, with a mean proportion of 0.87 ($SD = 0.12$). This dominance of two-wheelers may be attributed to their ability to filter through gaps and position themselves in leading queue locations during congestion, as well as their relatively better acceleration characteristics compared to other vehicle types. In contrast, car proportion remained relatively low (Mean = 0.09, $SD = 0.09$),

while light vehicles and heavy vehicles constituted only marginal shares of the traffic stream, with mean proportions of 0.02 and 0.02 respectively, exhibiting limited variability.

Table 4.1: Descriptive Statistics of Variables

Variable	Minimum	Maximum	Mean	Std. Deviation
Headway (seconds)	0.636	3.636	1.133	0.462
NC	0	9	1.118	1.621
TW	0.417	1	0.872	0.116
Car	0	0.462	0.085	0.093
LV	0	0.25	0.023	0.047
HV	0	0.167	0.02	0.037
Volume (PCU/lane/phase)	7	92	42.891	21.132

4.1.2 Categorical Variables

The distribution of categorical variables was examined to understand the composition of traffic movements and intersection characteristics within the dataset.

Movement Type

The distribution of vehicle movement types in dataset is illustrated in figure 4.1. Three movement categories were identified: Shared, Through, and Right. Shared movements (Shared) accounted for the largest no of observations (n = 166), followed by Through movements (Through) (n = 120) and Right-turn movements (Right) (n = 121). The observed distribution reflects both the operational characteristics of the intersection and the adopted observation framework, and therefore may not represent the natural proportion of movement types in the traffic stream.

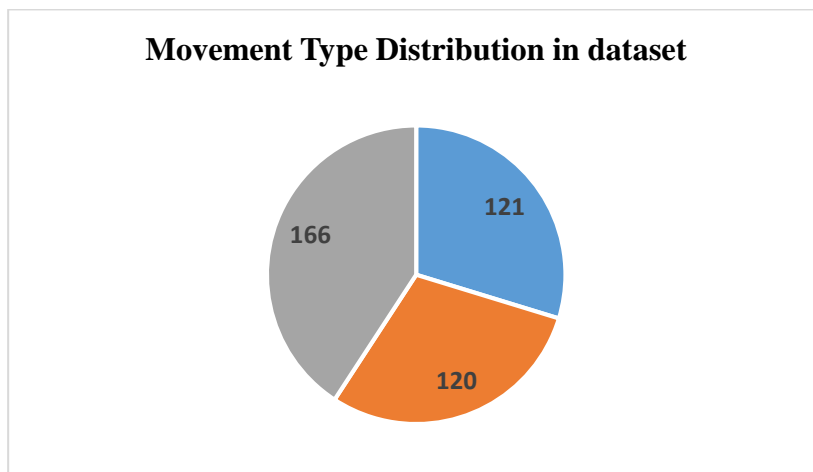


Figure 4.1: Movement type distribution

Approach Type (Approach):

The distribution of approach types in the dataset is illustrated in Figure 4.2. Observations were classified into approaches operating under shared signal phases and those operating under separate phases for through and right-turn movements. A higher number of observations corresponds to approaches with separate-phase operations ($n = 241$), while shared-phase approaches account for ($n = 166$). This distribution is influenced by differences in signal phasing across approaches, which affect the number of observable cycles. Consequently, the proportions reflect the intersection's operational structure and observation framework rather than the actual traffic distribution across approach types.

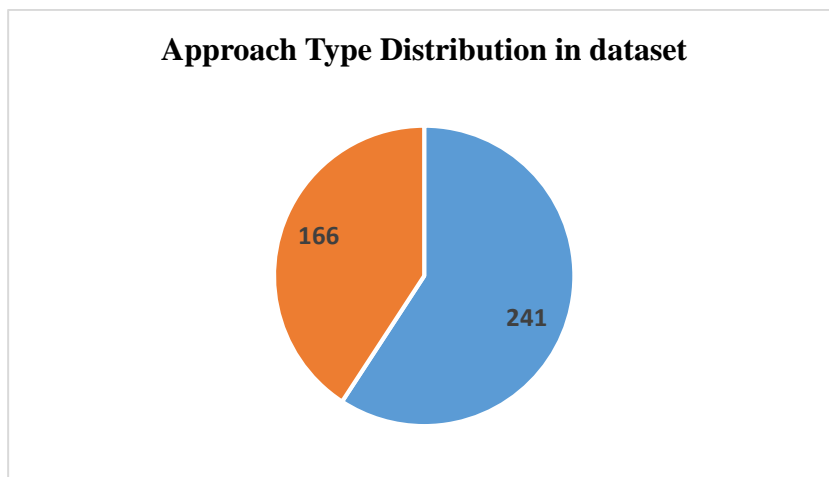


Figure 4.2: Approach Type Distribution in dataset

4.2 Independent t test

An independent samples t-test was conducted to determine whether vehicular headway differs significantly between phases with and without pedestrian non-compliance. The test compared log-transformed headway between two independent groups: Compliance phases ($NC = 0$) and Non-compliance phases ($NC \geq 1$). Levene's test indicated a violation of the equal variances assumption ($F = 7.239$, $p = 0.007$); therefore, results assuming unequal variances were interpreted. A statistically significant difference in log-transformed headway was observed between compliance and non-compliance phases ($t = -6.965$, $df = 385.742$, $p < 0.001$). Non-compliance phases had significantly higher log headway ($M = 0.176$, $SD = 0.351$) compared to Compliance phases ($M = -0.05$, $SD = 0.301$). The mean difference was -0.226 (95% CI: -0.290 to -0.163), with the confidence interval excluding zero, further confirming statistical significance. Back-transformed geometric means revealed that non-

compliance phases had a mean headway of 1.19 seconds, while compliance phases had a mean headway of 0.95 seconds, indicating longer headways when pedestrian non-compliance was present. Since the p-value (< 0.001) is less than the significance level ($\alpha = 0.05$), the null hypothesis is rejected. This indicates that pedestrian non-compliance has a statistically significant effect on vehicular headway. Table 4.2 and 4.3 presents the Group Statistics for Log-Transformed Headway by Non-compliance Status and independent samples t-test results respectively.

Table 4.2: Group Statistics for Log-Transformed Headway by Non-compliance Status

Noncompliance Status	N	Mean ln(h)	Std. Deviation	Std. Error Mean
Compliance (0)	211	-0.0499	0.301	0.021
Non-compliance (1)	196	0.176	0.351	0.025

Table 4.3: Independent t test

Variable	Assumption	Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
ln(h)	Equal variances assumed	7.239	0.007	-7.004	405	$< .001$	-0.22648	0.03234
	Equal variances not assumed			-6.965	385.742	$< .001$	-0.22648	0.03252

4.3 Correlation Analysis

Having established a significant difference in headways due to pedestrian non-compliance (NC), Pearson correlation coefficients were calculated to further examine relationships among the independent variables and to assess potential multicollinearity concerns prior to regression modeling. Table 4.4 presents the correlation matrix.

Pedestrian non-compliance (NC), the primary independent variable of this study, exhibited weak correlations with all other independent variables, with the highest correlation observed with light vehicle proportion (LV) ($r = 0.152$), which is well below the threshold of concern. This indicates that pedestrian non-compliance behaves relatively independently of other traffic characteristics and provides distinct explanatory power for modeling vehicular headway. Among the remaining independent variables, several strong correlations were observed. Traffic volume exhibited a strong negative correlation with right-turn movement ($r = -0.843$) and a strong positive correlation with shared movement ($r = 0.766$). Additionally, a high negative correlation was found between two-wheeler proportion and

car proportion ($r = -0.837$), reflecting the compositional dependency among vehicle categories within the traffic stream.

A perfect correlation ($r = 1.00$) was observed between approach type (Approach) and shared movement. This indicates that the two variables convey identical information and cannot be included simultaneously in the regression model. Based on these findings, traffic volume (Volume) and approach type (Approach) were excluded from the regression model. Car proportion (Car) was treated as the reference category due to its high correlation with two-wheeler proportion and to avoid perfect multicollinearity arising from the unit-sum constraint of vehicle composition variables. Similarly, through movement (Through) was used as the reference category among movement-type variables to avoid the dummy variable trap. Overall, the correlation analysis confirms that pedestrian non-compliance is not strongly associated with other predictors, thereby supporting its inclusion as a key independent variable in the regression model to assess its impact on vehicular headway.

Table 4.4: Pearson Correlation Matrix

Variable	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
NC	1									
TW	-.148**	1								
Car	.084	-.837**	1							
LV	.152**	-.530**	.104*	1						
HV	0.06	-.337**	-.034	.113*	1					
Volume	-0.072	.568**	-.476**	-.290**	-.203**	1				
Right	.125*	-.654**	.560**	.342**	.186**	-.843**	1			
Shared	-0.002	.309**	-.256**	-.178**	-.091	.766**	-.540**	1		
Through	-.124*	.322**	-.285**	-.151**	-.088	.019	-.421**	-.537**	1	
Approach	-.002	.309**	-.256**	-.178**	-.091	.766**	-.540**	1.000**	-.537**	1

Note: ** signifies correlation is significant at the 0.01 level (2-tailed).

*signifies correlation is significant at the 0.05 level (2-tailed)

4.4 Multiple Linear Regression Results

Multiple linear regression was employed to quantify the relationship between vehicular headway and the selected explanatory variables. The dependent variable was transformed using the natural logarithm [$\ln(h)$]. Initially, all selected independent variables were entered into the model. However, light vehicle proportion (LV) and shared movement type (Shared) were found to be statistically insignificant and was therefore excluded from the final model. This section presents the model fit statistics, ANOVA results and regression coefficients.

4.4.1 Time Headway Model for the Intersection

A multiple linear regression was conducted to model the factors affecting vehicular headway. The regression model explains 84% of the variance in log-transformed headway ($R^2 = 0.84$, Adjusted $R^2 = 0.838$), indicating excellent model fit. Table 4.5 presents the complete model summary.

Table 4.5: Model Summary

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate	Durbin-Watson
1	0.916	0.84	0.838	0.1386	1.905

Analysis of variance (ANOVA) was conducted to test the overall significance of the regression model. The results confirm that the model is statistically significant ($F = 527.194$, $p < 0.001$), indicating that the predictors collectively explain a significant portion of headway variation. Table 4.6 presents the complete ANOVA results.

Table 4.6: ANOVA

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	40.522	4	10.131	527.194	< 0.001
Residual	7.725	402	0.019		
Total	48.247	406			

The regression coefficients of the final model are presented in Table 4.7. All included variables were statistically significant at the 95% confidence level ($p < 0.001$), indicating that each variable contributes meaningfully to explaining variations in log-transformed vehicular headway.

Pedestrian non-compliance (NC) was found to have a statistically significant positive effect on vehicular headway ($B = 0.058$, $p < 0.001$). This indicates that each additional non-compliant pedestrian crossing during the red signal phase increases vehicular headway by

approximately 5.97% ($e^{0.058} = 1.0597$), holding all other variables constant. The standardized coefficient (Beta = 0.273) indicates that pedestrian non-compliance (NC) has a relatively strong influence on headway among the predictor variables, ranking after right turning movement (Right), (Beta = 0.483) and TW (Beta = -0.396).

In terms of magnitude, this effect is operationally meaningful. Although this increase may appear small at the individual level, its cumulative effect across multiple cycles can significantly reduce intersection discharge efficiency and overall capacity. This confirms that pedestrian non-compliance is a significant behavioral factor contributing to increased headway at the study intersection. During the vehicular discharge period, illegal pedestrian crossings disrupt the movement of queued vehicles, forcing drivers to decelerate or brake. This disturbance propagates downstream, increasing the temporal spacing between successive vehicles and reducing the smoothness of flow.

Although no prior local studies have directly quantified this relationship, the findings are consistent with international research. Chen et al. (2016) reported that pedestrian interference can significantly reduce capacity at signalized intersections. Similarly, Rabbi et al. (2025), in a study conducted in Dhaka, Bangladesh, found that illegal pedestrian crossings during the vehicular green phase increased vehicular headways. The relatively higher effect observed in the present study may also be influenced by the adopted headway measurement approach and prevailing traffic composition. The traffic stream at the study intersection was heavily dominated by two-wheelers, which typically exhibit much lower headways compared to other vehicle types. As a result, even small absolute increases in headway caused by pedestrian non-compliance translate into larger relative changes in the log-transformed model. This may partially explain why the estimated effect size is higher than that reported in comparable studies. Therefore, the results should be interpreted in the context of the prevailing traffic composition and measurement framework.

Two-Wheeler Proportion (TW) was found to have a statistically significant negative effect on vehicular headway ($B = -1.181$, $p < 0.001$). This indicates that a 10% increase in the proportion of two-wheelers reduces headway by approximately 11.14%, holding other variables constant. This substantial reduction reflects the inherent maneuverability of two-wheelers, which can occupy smaller gaps, perform lateral filtering, and maintain closer following distances compared to larger vehicles. As a result, traffic streams with a higher proportion of two-wheelers tend to exhibit more compact discharge patterns and higher flow rates. This finding is consistent with the study by Neupane (2020), which also reported that increasing two-wheeler proportion reduces headway and enhances flow efficiency.

However, this behavior challenges the direct applicability of conventional methodologies such as the Highway Capacity Manual, which are primarily based on homogeneous or lane-disciplined traffic conditions and may not adequately capture the dynamics of mixed traffic with high two-wheeler presence.

Heavy Vehicle Proportion (HV) shows a statistically significant positive effect on headway ($B = 0.941, p < 0.001$), indicating that a 10% increase in heavy vehicles results in an approximate 9.87% increase in headway. This is expected, as heavy vehicles exhibit slower acceleration characteristics, larger physical dimensions, and greater spacing requirements, all of which contribute to increased temporal gaps between successive vehicles during queue discharge. The presence of heavy vehicles therefore reduces the compactness of traffic flow and lowers intersection discharge efficiency.

Right-turning movement (Right) also demonstrates a statistically significant positive effect on headway ($B = 0.364, p < 0.001$), with right-turning vehicles experiencing approximately 43.9% higher headway compared to through movements. This is consistent with fundamental traffic engineering principles, as right-turning vehicles have reduced turning speeds, and more complex maneuvering requirements. The relatively high magnitude observed in this study may further be attributed to geometric and operational constraints at the study intersection, particularly the limited width of the right-turn pocket lane and lateral interference from adjacent through traffic. These factors restrict vehicle movement and disrupt smooth discharge, thereby increasing headway. This highlights the importance of intersection design and lane allocation in influencing operational performance.

Overall, the results demonstrate that while traffic composition and turning movements significantly influence headway, pedestrian non-compliance remains an independent and meaningful contributor to increased vehicular headway. This highlights the critical role of pedestrian behavior in shaping intersection operational performance under mixed traffic conditions.

Table 4.7: Regression Coefficients

Variable	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	VIF
Constant	0.896	0.078		11.541	<0.001	0.744	1.049	
TW	-1.181	0.082	-0.396	-14.327	<0.001	-1.343	-1.019	1.92
HV	0.941	0.198	0.101	4.760	<0.001	0.552	1.329	1.131
NC	0.058	0.004	0.273	13.540	<0.001	0.05	0.067	1.024
Right	0.364	0.02	0.483	18.291	<0.001	0.325	0.403	1.754

4.5 Model Diagnostics and Validation

4.5.1 Model Diagnostics

Several diagnostic checks were conducted to ensure that the underlying assumptions of multiple linear regression were met. In addition, model validation procedures were performed to assess the generalizability of the model.

Multicollinearity: The presence of multicollinearity among the predictors was assessed using the Variance Inflation Factor (VIF). The VIF values for all predictors were calculated to be less than 2 as shown in Table 4.7. Because these values fall well below the conventional threshold of 5, this indicates that no significant multicollinearity is present, meaning the independent variables are distinct from one another.

Autocorrelation: The assumption of independent errors was tested using the Durbin-Watson statistic. The analysis yielded a Durbin-Watson value of 1.905 as shown in Table 4.5. This value falls comfortably within the acceptable range of 1.5 to 2.5, confirming that there is no significant first-order linear autocorrelation in the regression data.

Homoscedasticity: The assumption of homoscedasticity, which requires the variance of the residuals to be constant across all levels of the predicted values, was evaluated visually. As shown in Appendix B, Figure B.1 (scatterplot of standardized residuals versus standardized predicted values), the data points are randomly scattered around the horizontal zero line. No distinct funnel, fan, or bow-tie shape is observed, confirming that the constant variance assumption is satisfied.

Influential Observations (Cook's Distance): To identify any extreme outliers that might be disproportionately skewing the regression model, Cook's Distance was calculated for all cases. The maximum Cook's Distance value in the dataset was found to be less than 0.1. Because this is well below the conventional threshold of 1.0, it confirms that no single observation exerted an undue influence on the regression model's coefficients, ensuring the overall stability and reliability of the model.

Linearity: The assumption of a linear relationship between the independent variables and the dependent variable, $\ln(h)$, was verified using partial regression plots as shown in (Appendix B, Figures B.2-B.5). The plots for the individual predictors (Right, NC, HV, and TW) exhibit clear linear trends (either positive or negative) without distinct curvature, indicating that the linearity assumption is adequately met for this model.

Normality of Residuals: The assumption that the residuals are normally distributed was assessed using a normal quantile-quantile (Q-Q) plot. Visual inspection of the Q-Q plot, as shown in (Appendix B, Figure B.6) demonstrated that the residuals closely followed the diagonal reference line with slight deviations in tails, indicating that the normality assumption is reasonably satisfied. Given the adequately large sample size ($N = 407$), this visual confirmation is considered robust for the purposes of this regression analysis.

4.5.2 Model Validation

To assess model generalizability, the dataset was randomly split into training (70%, $n = 285$) and validation (30%, $n = 122$) sets. The training model achieved an R^2 of 0.836 (Adjusted $R^2 = 0.834$), closely matching the full model's performance. When applied to the validation set, the model yielded an R^2 of 0.846 with a root mean squared error (RMSE) of 0.14, indicating strong predictive accuracy. The close agreement between training and validation performance demonstrates that the model captures genuine relationships rather than overfitting to noise in the estimation sample. Results are presented in (Appendix B, Table B.2 – B.5)

4.6 Effect of Pedestrian Non-Compliance under Shared and Separate Signal Phases

Two multiple linear regression models were developed to examine and compare the effect of pedestrian non-compliance on vehicular headways across approaches operating under shared signal phases and those with separate phases for through and right-turn movements.

4.6.1 Approach operating under Separate Phases

The Basundhara-Maharajgunj and Chabahil-Maharajgunj approaches operate with separate signal phases for through and right turning movements. Each approach consists of four incoming lanes: one free left-turning lane, two through lane groups, and one right-turn pocket lane. A categorical variable called "Type" represents the vehicular movement type. It was coded as 0 for through movement and 1 for right-turning movement. Through movement was used as the reference category in the analysis. Pearson correlation coefficients were calculated to examine relationships among the independent variables in major approaches and to assess potential multicollinearity concerns prior to regression modeling. Table 4.8 presents the Pearson correlation matrix.

Table 4.8: Pearson correlation matrix (Separate Phases)

Variable	NC	Type	TW	Car	LV	HV	Volume
NC	1						
Type	.195**	1					
TW	-0.237**	-.698**	1				
Car	0.138*	0.592**	-0.820**	1			
LV	0.180**	0.327**	-0.500**	0.019	1		
HV	0.149*	0.205**	-0.335**	-0.034	0.134*	1	
Volume	-0.181**	-0.948**	0.713**	-0.618**	-0.320**	-0.195**	1

Note: ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The correlation analysis showed that pedestrian non-compliance (NC) had weak relation with all other independent variables. This indicates that pedestrian non-compliance behaves relatively independently of other traffic characteristics and provides distinct explanatory power for modeling vehicular headway. Among the remaining independent variables, several strong correlations were observed. Volume exhibited a strong negative correlation with movement type (Type) ($r = -0.943$) and a strong positive correlation with Two wheeler proportion (TW) ($r = 0.713$). Additionally, a high negative correlation was found between TW and Car ($r = -0.820$), reflecting the compositional dependency among vehicle categories within the traffic stream. Hence, Volume and Car were dropped from regression analysis. Car was reference category among vehicle composition variables.

Multiple linear regression was employed to quantify the relationship between vehicular headway and the selected explanatory variables. The dependent variable was transformed using the natural logarithm [$\ln(h)$]. Initially, all selected independent variables were entered into the model. However, light vehicle proportion (LV) was found to be statistically insignificant and was therefore excluded from the final model. The final regression model explains 83.1% of the variance in headways ($R^2 = .831$, Adjusted $R^2 = 0.828$). Darwin-Watson value of model fall in acceptable range suggesting no autocorrelation in residuals. ANOVA result confirms the model is statistically significant ($F(4, 236) = 289.66$, $p < 0.001$). Table 4.9 and Table 4.10 present model summary and ANOVA result of final model.

Table 4.9: Model Summary (Separate Phases)

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate	Durbin-Watson
1	0.911	0.831	0.828	0.160047	1.884

Table 4.10: ANOVA (Separate Phases)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	29.679	4	7.42	289.659	<0.001
Residual	6.045	236	0.026		
Total	35.724	240			

Pedestrian non-compliance (NC) was found to have a statistically significant positive effect on vehicular headway ($B = 0.055$, $p < 0.001$). This indicates that each additional non-compliant pedestrian crossing during the red signal phase increases vehicular headway on approaches with separate phases by approximately 5.65% ($e^{0.055} = 1.0565$), holding all other variables constant. The regression coefficient are presented in Table 4.11

Table 4.11: Regression coefficient (Separate Phases)

Variable	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	VIF
Constant	1.097	0.115		9.504	<0.001	0.869	1.324	
NC	0.055	0.007	0.227	8.215	<0.001	0.042	0.068	1.068
Type	0.321	0.029	0.416	11.116	<0.001	0.264	0.378	2.138
TW	-1.383	0.121	-0.447	-11.418	<0.001	-1.621	-1.144	1.135
HV	0.971	0.289	0.096	3.364	<0.001	0.402	1.539	1.958

4.6.2 Approach operating under Shared Phase

The Budhanilkantha-Maharajgunj approach operates under a shared phase for through and right turning movements. This approach consists of two incoming lanes: one free left-turning lane and one lane for through and right turning movement. The variable, Type was not considered in analysis for this approach, as both movements operate under same phase and utilize same lane. Pearson correlation coefficients were computed among independent variables in minor approach as well prior to regression modeling. Table 4.12 present Pearson correlation matrix

Table 4.12: Pearson correlation matrix (Shared Phase)

Variable	NC	TW	Car	LV	HV	Volume
NC	1					
TW	0.005	1				
Car	-0.018	-.836**	1			
LV	0.111	-.547**	.230**	1		
HV	-0.074	-.316**	-0.125	0.006	1	
Volume	0.009	0.09	0.014	-0.004	-.240**	1

Note: ** Correlation is significant at the 0.01 level (2-tailed).

The correlation analysis showed that pedestrian non-compliance (NC) had weak relation with all other independent variables. This indicates that pedestrian non-compliance behaves relatively independently of other traffic characteristics and provides distinct explanatory power for modeling vehicular headway. Among the remaining independent variables, TW and Car exhibited a strong negative correlation ($r = -0.836$). As a result, Car was dropped from regression model and treated as reference category among vehicle composition. All other independent variables were entered into the model. However, light vehicle proportion (LV) and Volume were found to be statistically insignificant and were therefore excluded from the final model. The final model explains 66.7% of the variance in headways ($R^2 = 0.667$, Adjusted $R^2 = 0.66$). Durbin-Watson value of model fall in acceptable range suggesting no autocorrelation in residuals. ANOVA result confirms the model is statistically significant ($F(3, 162) = 107.934$, $p < 0.001$). Table 4.13 and Table 4.14 present model summary and ANOVA result of minor approach.

Table 4.13: Model Summary (Shared Phase)

Model	R	R ²	Adjusted R ²	Std. Error of the Estimate	Durbin-Watson
1	0.816	0.667	0.660	0.09509	1.881

Table 4.14: ANOVA (Shared Phase)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	2.928	3	0.976	107.934	<0.001
Residual	1.465	162	0.009		
Total	4.393	165			

Pedestrian non-compliance (NC) was found to have a statistically significant positive effect on vehicular headway ($B = 0.061$, $p < 0.001$). This indicates that each additional non-compliant pedestrian crossing during the red signal phase increases vehicular headway on approach with shared phase by approximately 6.28% ($e^{0.061} = 1.0628$), holding all other variables constant. The regression coefficient are presented in Table 15.

Table 4.15: Regression coefficient (Shared Phase)

Variable	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	VIF
Constant	0.606	0.086		7.038	<0.001	0.436	0.776	
NC	0.061	0.004	0.619	13.599	<0.001	0.052	0.07	1.006
TW	-0.875	0.092	-0.453	-9.479	<0.001	-1.057	-0.693	1.111
HV	0.947	0.223	0.204	4.244	<0.001	0.506	1.388	1.117

4.6.3 Discussion

Pedestrian non-compliance (NC) was found to have a statistically significant positive effect on vehicular headway in both approach types ($p < 0.001$), confirming that illegal pedestrian crossings consistently disrupt vehicular discharge under mixed traffic conditions. However, the magnitude of this effect is slightly higher for approaches operating under shared phase, where NC increases headway by approximately 6.28% ($B = 0.061$), compared to 5.65% ($B = 0.055$) for approaches operating under separate phases.

This variation can be attributed to differences in lane configuration, signal phasing, and operational friction. In both cases, the presence of a free left-turn lane minimizes the influence of left-turn movements on headway differences. However, approaches operating under separate phases include a dedicated right-turn pocket lane, which experiences notable operational constraints due to lateral friction from adjacent through traffic, further exacerbated by weak lane discipline. Consequently, right-turning vehicles on these approaches already experience relatively higher and more variable headways. In contrast, approaches operating under a shared phase accommodate both through and right-turning movements within the same stream, resulting in comparatively lower lateral friction between movements. Because approaches with separate phases already exhibit higher baseline headway variability due to geometric and operational constraints, the incremental effect of pedestrian non-compliance appears relatively smaller. In other words, the impact of NC is partially masked by existing frictional effects. Conversely, under shared phase conditions, where traffic flow is more uniform and less constrained, the influence of pedestrian non-compliance becomes more pronounced.

Despite these differences, the consistent statistical significance of NC across both models confirms that pedestrian non-compliance is a robust determinant of vehicular headway under mixed traffic conditions. The findings further suggest that the magnitude of its effect is context-dependent, influenced by intersection geometry, signal phasing, and lane discipline.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study investigated the impact of pedestrian non-compliance on vehicular headway at signalized intersection, using Maharajgunj Intersection as a case study. Based on 407 observations and statistical analysis including an independent samples t-test and multiple linear regression, the study provides clear evidence of pedestrian non-compliance on vehicular headway under mixed traffic conditions. The major conclusions drawn from the study are:

- Pedestrian non-compliance significantly increases base vehicular headways. An independent samples t-test confirmed that phases with pedestrian non-compliance exhibited a statistically significant higher mean headway of 1.19 seconds compared to 0.95 seconds during phases with no pedestrian noncompliance ($p < 0.001$).
- There is a quantifiable, positive correlation between the frequency of pedestrian violations and increased vehicular headway under heterogeneous traffic conditions. The overall intersection multiple linear regression model ($R^2 = 0.84$) demonstrated that each additional non-compliant pedestrian crossing during the red signal phase increases vehicular headway by approximately 5.97% ($B = 0.058$, $p < 0.001$).
- Traffic composition and movement types significantly influence intersection discharge efficiency alongside pedestrian behavior. The analysis revealed that a 10% increase in two-wheeler proportion reduces headway by approximately 11.14% ($B = -1.181$, $p < 0.001$), while a 10% increase in heavy vehicles increases headway by 9.87% ($B = 0.941$, $p < 0.001$). Furthermore, right-turning movements experience roughly 43.9% higher headways compared to through movements ($B = 0.364$, $p < 0.001$).
- Pedestrian non-compliance has a context-dependent impact on vehicular headways, with greater sensitivity observed under shared phase conditions. Although it remains a statistically significant determinant in both cases ($p < 0.001$), its effect is more pronounced for approaches operating under a shared phase, where headway increases by 6.28% ($B = 0.061$), compared to a 5.65% increase ($B = 0.055$) for approaches operating under separate phases.

5.2 Recommendations

Based on the findings of this study conducted at Maharajgunj Intersection, several measures are recommended to improve traffic flow efficiency and safety at signalized intersections under mixed traffic conditions. First, signal timing should be optimized to better manage interactions between pedestrians and vehicles at intersections with high pedestrian activity. Improvements in intersection geometry, clearer lane markings and lane discipline can facilitate smoother vehicle discharge. Additionally, managing traffic composition through partial segregation of vehicle types and restricting heavy vehicle movement during peak hours may further enhance operational efficiency.

While these measures can significantly improve current intersection performance, further research is recommended to strengthen and generalize these findings. Future studies should consider multiple intersections and varying traffic conditions to validate the results across different contexts. Incorporating additional factors, such as driver response patterns, would provide deeper insights into traffic interactions. Moreover, the use of advanced data collection techniques, including computer vision and machine learning, could improve the accuracy and efficiency of headway measurement in mixed traffic environments.

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APPENDIX A: RAW INPUT DATA

Sample Data Extraction:

Name of Approach: Chabahil-Maharajgunj

Date: 2026/01/11

Time: 10-11AM

Observations	Movement Type	Lane	Time(Sec)	TW	Car	LV	HV	NC	Avg. NC	Headway	Avg. Headway	ln(h)
1	Right		14	10	1	0	1	0	0	1.27	1.27	0.24
2	Straight	1	10	12	0	0	0	2	2	0.91	1.00	0.00
		2	12	10	2	0	0	2		1.09		
3	Right		17	8	3	0	1	1	1	1.55	1.55	0.44
4	Straight	1	13	11	1	0	0	2	2	1.18	1.09	0.09
		2	11	10	1	0	1	0		1.00		
5	Right		12	11	0	0	1	0	0	1.09	1.09	0.09
6	Straight	1	9	12	0	0	0	0	1	0.82	1.05	0.04
		2	14	11	0	0	1	2		1.27		
7	Right		9	11	1	0	0	0	0	0.82	0.82	-0.20
8	Straight	1	12	12	0	0	0	0	0	1.09	1.00	0.00
		2	10	11	0	0	1	0		0.91		
9	Right		19	9	3	0	0	2	2	1.73	1.73	0.55
10	Right		18	9	3	0	0	4	4	1.64	1.64	0.49
11	Straight	1	11	12	0	0	0	0	0	1.00	1.09	0.09
		2	13	9	3	0	0	0		1.18		
12	Right		13	11	1	0	0	1	1	1.18	1.18	0.17
13	Straight	1	18	8	3	0	0	4	2	1.64	1.27	0.24
		2	10	11	1	0	0	0		0.91		
14	Right		13	10	2	0	0	0	0	1.18	1.18	0.17
			14	9	3	0	0	0		1.27		
15	Straight	1	14	9	3	0	0	0	0	1.27	1.09	0.09
		2	10	11	0	1	0	0		0.91		
16	Right		12	11	1	0	0	0	0	1.09	1.09	0.09
17	Straight	1	9	11	0	1	0	0	0	0.82	0.77	-0.26
		2	8	12	0	0	0	0		0.73		
18	Right		17	9	2	1	0	1	1	1.55	1.55	0.44
19	Straight	1	12	10	2	0	0	0	0	1.09	0.86	-0.15
		2	7	12	0	0	0	0		0.64		
20	Right		17	10	2	0	0	1	1	1.55	1.55	0.44
21	Straight	1	9	12	0	0	0	1	1	0.82	0.91	-0.10
		2	11	11	1	0	0	1		1.00		
22	Right		15	10	2	0	0	0	0	1.36	1.36	0.31
23	Straight	1	13	12	0	0	0	3	3	1.18	1.27	0.24
		2	15	11	1	0	0	3		1.36		
24	Right		20	10	2	0	0	2	2	1.82	1.82	0.60
25	Straight	1	9	12	0	0	0	0	0	0.82	0.77	-0.26
		2	8	12	0	0	0	0		0.73		

Sample Data Extraction (Volume Count)

Name of Approach: Chabahil-Maharajgunj Approach

Date: 2026/01/11

Time: 10-11AM

Observations	Movement Type	TW	car	LV	HV	Volume(PCU)	PCU/lane
1	Right	29	6	0	2	19.25	19.25
2	Straight	106	22	8	12	96.5	48.25
3	Right	17	6	2	3	22.25	22.25
4	Straight	65	20	6	8	69.25	34.625
5	Right	29	12	0	1	22.25	22.25
6	Straight	72	18	8	8	72	36
7	Right	29	6	1	0	14.75	14.75
8	Straight	84	17	9	13	90.5	45.25
9	Right	22	9	1	0	16	16
10	Right	21	10	1	0	16.75	16.75
11	Straight	70	20	7	8	72	36
12	Right	23	7	1	0	14.25	14.25
13	Straight	122	28	3	10	93	46.5
14	Right	30	9	0	2	22.5	22.5
15	Straight	115	26	5	12	98.25	49.125
16	Right	29	8	1	0	16.75	16.75
17	Straight	112	24	9	10	95.5	47.75
18	Right	25	9	1	1	19.75	19.75
19	Straight	99	19	6	9	79.75	39.875
20	Right	29	5	1	1	16.75	16.75
21	Straight	109	22	4	5	70.25	35.125
22	Right	25	9	0	0	15.25	15.25
23	Straight	103	23	10	10	93.75	46.875
24	Right	26	10	0	1	19.5	19.5
25	Straight	99	27	6	8	84.75	42.375

Input data:

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
-0.405	0	0.958	0.042	0	0	43	0	0	1	0
-0.182	0	0.833	0.125	0	0.042	38	0	0	1	0
-0.288	1	0.917	0.083	0	0	51	0	0	1	0
-0.182	3	0.917	0	0.083	0	53	0	0	1	0
0.288	1	0.875	0.083	0	0.042	45	0	0	1	0
-0.288	0	0.917	0	0.083	0	42	0	0	1	0
-0.405	0	1	0	0	0	50	0	0	1	0
-0.405	0	0.958	0	0.042	0	42	0	0	1	0
-0.405	0	1	0	0	0	43	0	0	1	0
0.000	3	0.958	0	0	0.042	42	0	0	1	0
0.000	5	1	0	0	0	44	0	0	1	0
-0.446	0	0.92	0.04	0	0.04	48	0	0	1	0
-0.087	2	0.917	0	0.042	0.042	48	0	0	1	0
-0.087	2	0.958	0	0	0.042	45	0	0	1	0
-0.405	0	0.958	0.042	0	0	48	0	0	1	0
-0.288	1	0.958	0.042	0	0	49	0	0	1	0
-0.288	0	0.958	0	0	0.042	41	0	0	1	0
-0.087	4	0.958	0.042	0	0	47	0	0	1	0
-0.087	1	0.917	0.042	0	0.042	39	0	0	1	0
-0.288	0	0.958	0.042	0	0	41	0	0	1	0
-0.405	0	1	0	0	0	49	0	0	1	0
-0.288	1	0.958	0	0.042	0	45	0	0	1	0
-0.539	0	0.875	0.125	0	0	45	0	0	1	0
-0.405	0	0.958	0.042	0	0	36	0	0	1	0
-0.087	0	0.958	0	0	0.042	39	0	0	1	0
0.154	5	0.917	0.042	0	0.042	46	0	0	1	0
-0.087	2	0.958	0	0	0.042	39	0	0	1	0
-0.288	0	0.917	0	0.042	0.042	50	0	0	1	0
-0.405	1	0.917	0.083	0	0	47	0	0	1	0
-0.405	0	0.917	0.042	0	0.042	45	0	0	1	0
-0.539	0	1	0	0	0	45	0	0	1	0
-0.087	2	0.917	0.042	0	0.042	49	0	0	1	0
-0.087	5	1	0	0	0	50	0	0	1	0
-0.288	1	0.917	0.083	0	0	38	0	0	1	0
0.043	0	0.957	0.043	0	0	43	0	0	1	0
-0.223	3	0.96	0.04	0	0	49	0	0	1	0
-0.405	1	0.958	0.042	0	0	45	0	0	1	0
-0.405	0	0.958	0.042	0	0	34	0	0	1	0
0.080	3	0.875	0	0	0.125	44	0	0	1	0
-0.539	0	1	0	0	0	49	0	0	1	0
-0.288	1	0.917	0	0.083	0	45	0	0	1	0
-0.288	2	0.875	0.042	0.042	0.042	50	0	0	1	0
-0.405	0	1	0	0	0	47	0	0	1	0

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
-0.405	2	1	0	0	0	48	0	0	1	0
-0.539	0	0.958	0	0.042	0	45	0	0	1	0
-0.087	0	0.875	0.042	0.042	0.042	43	0	0	1	0
-0.288	3	0.917	0.042	0.042	0	48	0	0	1	0
-0.539	0	1	0	0	0	43	0	0	1	0
-0.288	0	0.958	0.042	0	0	46	0	0	1	0
-0.182	0	0.917	0.083	0	0	41	0	0	1	0
-0.405	0	1	0	0	0	54	0	0	1	0
-0.405	0	1	0	0	0	46	0	0	1	0
-0.288	0	0.875	0.125	0	0	47	0	0	1	0
-0.405	0	1	0	0	0	45	0	0	1	0
-0.405	0	1	0	0	0	50	0	0	1	0
-0.087	5	0.958	0.042	0	0	49	0	0	1	0
-0.405	0	0.958	0	0	0.042	49	0	0	1	0
-0.182	2	0.917	0.083	0	0	44	0	0	1	0
-0.182	2	0.958	0.042	0	0	47	0	0	1	0
-0.288	0	0.958	0	0	0.042	43	0	0	1	0
0.080	0	0.833	0.083	0	0.083	19	1	0	0	0
1.204	2	0.583	0.417	0	0	7	1	0	0	0
0.560	1	0.5	0.333	0.083	0.083	7	1	0	0	0
0.460	2	0.583	0.333	0	0.083	13	1	0	0	0
0.143	0	0.692	0	0.231	0.077	18	1	0	0	0
0.882	9	0.583	0.333	0.083	0	15	1	0	0	0
0.223	2	0.833	0.083	0	0.083	19	1	0	0	0
0.811	1	0.417	0.25	0.25	0.083	15	1	0	0	0
0.288	6	0.833	0.167	0	0	9	1	0	0	0
0.080	0	0.833	0.083	0.083	0	18	1	0	0	0
0.847	6	0.667	0.167	0.083	0.083	9	1	0	0	0
0.460	0	0.75	0.25	0	0	12	1	0	0	0
0.460	0	0.667	0.083	0.25	0	10	1	0	0	0
0.405	6	0.833	0.083	0.083	0	15	1	0	0	0
0.288	3	0.833	0.083	0	0.083	12	1	0	0	0
0.511	2	0.75	0	0.083	0.167	13	1	0	0	0
0.773	5	0.5	0.333	0.083	0.083	15	1	0	0	0
0.154	0	0.667	0.333	0	0	13	1	0	0	0
0.460	1	0.75	0	0.25	0	17	1	0	0	0
-0.087	0	0.833	0.083	0.083	0	15	1	0	0	0
0.431	4	0.692	0.077	0.154	0.077	16	1	0	0	0
0.693	5	0.667	0.083	0.25	0	11	1	0	0	0
0.821	7	0.727	0.091	0.091	0.091	19	1	0	0	0
0.802	1	0.462	0.462	0	0.077	9	1	0	0	0
0.223	2	0.75	0.083	0.167	0	23	1	0	0	0
0.154	3	0.833	0.167	0	0	18	1	0	0	0
0.000	1	0.833	0.083	0.083	0	19	1	0	0	0
0.288	2	0.75	0.167	0.083	0	18	1	0	0	0

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
0.511	2	0.75	0.167	0.083	0	17	1	0	0	0
0.560	1	0.667	0.167	0.083	0.083	13	1	0	0	0
0.223	2	0.75	0.25	0	0	14	1	0	0	0
0.560	3	0.833	0.083	0	0.083	9	1	0	0	0
0.651	0	0.583	0.25	0	0.167	19	1	0	0	0
0.916	3	0.583	0.333	0.083	0	11	1	0	0	0
0.511	0	0.75	0.083	0.083	0.083	9	1	0	0	0
0.405	1	0.833	0.083	0	0.083	16	1	0	0	0
0.288	2	0.833	0.083	0.083	0	20	1	0	0	0
0.223	1	0.917	0.083	0	0	15	1	0	0	0
0.460	1	0.75	0.25	0	0	10	1	0	0	0
0.916	5	0.667	0.083	0.083	0.167	13	1	0	0	0
0.310	4	0.818	0.182	0	0	19	1	0	0	0
0.460	0	0.75	0.167	0.083	0	11	1	0	0	0
0.080	0	0.667	0.167	0.167	0	13	1	0	0	0
0.833	6	0.6	0.4	0	0	10	1	0	0	0
0.606	1	0.75	0.083	0.167	0	11	1	0	0	0
0.288	3	0.833	0.083	0.083	0	15	1	0	0	0
0.405	3	0.833	0.083	0	0.083	17	1	0	0	0
0.223	0	0.833	0	0.167	0	13	1	0	0	0
0.511	0	0.833	0.083	0	0.083	14	1	0	0	0
0.916	0	0.583	0.083	0.167	0.167	15	1	0	0	0
0.348	0	0.667	0.083	0.167	0.083	19	1	0	0	0
0.460	0	0.833	0.167	0	0	14	1	0	0	0
0.511	0	0.833	0.167	0	0	17	1	0	0	0
0.606	2	0.833	0	0.083	0.083	8	1	0	0	0
0.651	2	0.583	0.25	0.083	0.083	11	1	0	0	0
0.651	4	0.583	0.167	0.25	0	19	1	0	0	0
0.348	0	0.583	0.25	0.167	0	11	1	0	0	0
0.223	0	0.833	0.167	0	0	14	1	0	0	0
0.560	3	0.75	0.167	0.083	0	13	1	0	0	0
0.348	4	0.833	0.083	0.083	0	21	1	0	0	0
0.511	2	0.667	0.333	0	0	9	1	0	0	0
-0.087	1	0.917	0.042	0.042	0	30	0	0	1	0
0.651	0	0.75	0.083	0.083	0	19	1	0	0	0
0.000	0	0.917	0	0	0.083	38	0	0	1	0
0.811	1	0.667	0.083	0.167	0.083	15	1	0	0	0
0.000	0	0.875	0.083	0	0.042	32	0	0	1	0
0.080	0	0.667	0.333	0	0	19	1	0	0	0
0.080	0.5	0.75	0.25	0	0	28	0	0	1	0
0.773	2	0.667	0.25	0.083	0	11	1	0	0	0
0.000	1.5	0.917	0.042	0	0.042	36	0	0	1	0
0.693	2	0.667	0.25	0.083	0	11	1	0	0	0
-0.405	0	0.958	0.042	0	0	45	0	0	1	0
0.651	2	0.583	0.333	0.083	0	17	1	0	0	0

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
-0.288	0	0.875	0.083	0	0.042	37	0	0	1	0
0.560	5	0.833	0.167	0	0	12	1	0	0	0
-0.345	0	0.833	0.125	0.042	0	43	0	0	1	0
0.511	0	0.917	0.083	0	0	16	1	0	0	0
-0.234	0	0.917	0.042	0.042	0	31	0	0	1	0
0.154	0	0.75	0.25	0	0	17	1	0	0	0
-0.470	0	0.958	0.042	0	0	37	0	0	1	0
0.811	5	0.75	0.167	0	0.083	11	1	0	0	0
-0.405	0	1	0	0	0	42	0	0	1	0
0.651	2	0.667	0.083	0.167	0.083	19	1	0	0	0
-0.539	0	0.958	0.042	0	0	32	0	0	1	0
0.154	0	0.667	0.333	0	0	17	1	0	0	0
-0.288	0	0.917	0.042	0.042	0	41	0	0	1	0
0.223	0	0.75	0.25	0	0	20	1	0	0	0
-0.087	1	0.917	0	0	0.083	51	0	0	1	0
0.080	2	0.917	0.083	0	0	20	1	0	0	0
-0.288	0	0.875	0.083	0.042	0	46	0	0	1	0
0.288	0	0.833	0.167	0	0	11	1	0	0	0
-0.405	0	1	0	0	0	44	0	0	1	0
0.288	0	0.833	0.167	0	0	13	1	0	0	0
0.189	3	0.792	0.083	0.042	0.083	51	0	0	1	0
0.154	0	0.833	0.167	0	0	11	1	0	0	0
-0.134	0.5	0.875	0.083	0	0.042	42	0	0	1	0
0.460	1	0.75	0.167	0	0.083	18	1	0	0	0
-0.405	0	1	0	0	0	43	0	0	1	0
0.080	2	0.833	0.083	0	0.083	23	1	0	0	0
-0.087	1	0.875	0.125	0	0	44	0	0	1	0
0.511	0	0.75	0.25	0	0	12	1	0	0	0
-0.087	1	0.917	0	0.083	0	39	0	0	1	0
0.511	2	0.75	0.25	0	0	17	1	0	0	0
0.041	1.5	0.875	0.083	0.042	0	46	0	0	1	0
0.651	2	0.75	0.083	0	0.167	18	1	0	0	0
-0.182	1	0.917	0.083	0	0	45	0	0	1	0
0.606	0	0.583	0.417	0	0	16	1	0	0	0
-0.234	0	0.917	0	0	0.083	41	0	0	1	0
0.651	0	0.5	0.417	0.083	0	21	1	0	0	0
-0.043	0	0.917	0.042	0	0.042	51	0	0	1	0
0.223	1	0.75	0.167	0	0.083	18	1	0	0	0
-0.234	0	0.917	0.042	0	0.042	45	0	0	1	0
0.000	1	1	0	0	0	21	1	0	0	0
-0.087	0	0.917	0	0.083	0	52	0	0	1	0
0.223	0	0.75	0.25	0	0	19	1	0	0	0
-0.288	0.5	0.917	0.042	0.042	0	44	0	0	1	0
0.154	0	0.833	0.167	0	0	20	1	0	0	0
0.000	0	0.917	0.042	0	0.042	53	0	0	1	0

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
0.223	0	0.833	0.167	0	0	21	1	0	0	0
-0.087	0	0.875	0.083	0	0.042	46	0	0	1	0
0.606	0	0.667	0.333	0	0	9	1	0	0	0
-0.134	1.5	0.917	0.042	0.042	0	50	0	0	1	0
0.405	0	0.833	0.167	0	0	14	1	0	0	0
-0.405	0	0.833	0.125	0.042	0	54	0	0	1	0
0.080	0	0.917	0.083	0	0	23	1	0	0	0
-0.234	0	0.833	0.167	0	0	38	0	0	1	0
0.080	0	0.833	0	0.083	0.083	19	1	0	0	0
-0.134	1	0.958	0.042	0	0	39	0	0	1	0
0.288	0	0.833	0.167	0	0	14	1	0	0	0
-0.405	0	0.958	0.042	0	0	39	0	0	1	0
0.154	0	0.833	0.167	0	0	17	1	0	0	0
-0.288	0.5	0.917	0.042	0.042	0	34	0	0	1	0
0.000	0	0.833	0.167	0	0	17	1	0	0	0
-0.288	1	0.958	0.042	0	0	46	0	0	1	0
-0.182	0	0.917	0.083	0	0	21	1	0	0	0
-0.182	0.5	0.917	0.042	0.042	0	42	0	0	1	0
0.693	0	0.833	0.167	0	0	16	1	0	0	0
-0.087	1	0.958	0.042	0	0	41	0	0	1	0
0.000	0	0.833	0.167	0	0	20	1	0	0	0
0.000	0	0.833	0.083	0.083	0	39	0	0	1	0
-0.405	0	1	0	0	0	18	1	0	0	0
0.000	3	1	0	0	0	49	0	0	1	0
0.288	0	0.75	0.25	0	0	16	1	0	0	0
-0.288	0	0.958	0.042	0	0	40	0	0	1	0
0.560	1	0.667	0.25	0	0.083	22	1	0	0	0
-0.043	0.5	0.917	0.083	0	0	36	0	0	1	0
0.560	0	0.833	0.083	0	0.083	11	1	0	0	0
-0.087	0	0.833	0.125	0.042	0.042	36	0	0	1	0
0.154	0	1	0	0	0	15	1	0	0	0
-0.345	0	0.917	0.083	0	0	37	0	0	1	0
0.693	0	0.583	0.417	0	0	15	1	0	0	0
-0.345	0	0.875	0.125	0	0	47	0	0	1	0
0.348	3	0.833	0.083	0.083	0	18	1	0	0	0
-0.043	1	0.958	0.042	0	0	37	0	0	1	0
0.288	1	0.75	0.083	0.083	0.083	22	1	0	0	0
-0.405	0.5	0.958	0.042	0	0	43	0	0	1	0
0.154	0	0.833	0.083	0	0.083	19	1	0	0	0
-0.087	2	0.917	0.083	0	0	48	0	0	1	0
0.348	1	0.667	0.25	0	0.083	22	1	0	0	0
0.000	1	0.875	0.083	0	0.042	35	0	0	1	0
0.000	0	0.917	0	0	0.083	22	1	0	0	0
-0.043	1	0.958	0	0	0.042	36	0	0	1	0
-0.288	0	0.917	0.083	0	0	15	1	0	0	0

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
-0.087	0	0.958	0	0	0.042	45	0	0	1	0
0.460	2	0.75	0.25	0	0	16	1	0	0	0
0.405	4	0.75	0.25	0	0	17	1	0	0	0
0.000	0	0.875	0.125	0	0	36	0	0	1	0
0.080	1	0.917	0.083	0	0	14	1	0	0	0
0.154	2	0.792	0.167	0	0.042	47	0	0	1	0
0.080	0	0.833	0.167	0	0	23	1	0	0	0
0.000	0	0.833	0.125	0.042	0	49	0	0	1	0
0.000	0	0.917	0.083	0	0	17	1	0	0	0
-0.345	0	0.958	0	0.042	0	48	0	0	1	0
0.348	1	0.75	0.167	0.083	0	20	1	0	0	0
-0.234	0	0.917	0.083	0	0	40	0	0	1	0
0.348	1	0.833	0.167	0	0	17	1	0	0	0
-0.182	1	0.958	0.042	0	0	35	0	0	1	0
0.223	0	0.833	0.167	0	0	15	1	0	0	0
0.154	3	0.958	0.042	0	0	47	0	0	1	0
0.511	2	0.833	0.167	0	0	20	1	0	0	0
-0.345	0	1	0	0	0	42	0	0	1	0
-0.087	0	0.667	0.25	0	0.083	68	0	1	0	1
0.223	6	0.667	0.25	0.083	0	65	0	1	0	1
-0.087	0	0.75	0.083	0	0.167	54	0	1	0	1
-0.182	0	0.917	0.083	0	0	56	0	1	0	1
-0.087	1	0.917	0	0	0.083	54	0	1	0	1
-0.182	0	0.833	0.167	0	0	51	0	1	0	1
-0.288	0	0.833	0.167	0	0	54	0	1	0	1
-0.288	0	1	0	0	0	57	0	1	0	1
-0.182	0	0.833	0.083	0	0.083	44	0	1	0	1
-0.087	0	0.667	0.25	0.083	0	52	0	1	0	1
0.080	1	0.583	0.333	0.083	0	64	0	1	0	1
-0.288	0	0.917	0.083	0	0	46	0	1	0	1
-0.288	0	0.917	0.083	0	0	58	0	1	0	1
0.154	1	0.833	0	0	0.167	45	0	1	0	1
-0.182	0	0.917	0	0	0.083	58	0	1	0	1
-0.288	0	0.833	0.167	0	0	42	0	1	0	1
-0.288	0	0.917	0.083	0	0	47	0	1	0	1
-0.182	1	0.917	0	0	0.083	55	0	1	0	1
-0.087	1	0.917	0.083	0	0	48	0	1	0	1
-0.087	1	0.917	0.083	0	0	55	0	1	0	1
-0.288	1	0.917	0.083	0	0	51	0	1	0	1
-0.288	0	0.917	0.083	0	0	65	0	1	0	1
-0.405	0	0.917	0.083	0	0	49	0	1	0	1
-0.288	0	1	0	0	0	44	0	1	0	1
-0.405	0	1	0	0	0	60	0	1	0	1
0.000	4	0.917	0.083	0	0	45	0	1	0	1
-0.288	0	0.833	0.167	0	0	56	0	1	0	1

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
-0.288	0	0.833	0.167	0	0	69	0	1	0	1
-0.405	0	1	0	0	0	72	0	1	0	1
-0.288	2	1	0	0	0	63	0	1	0	1
-0.405	0	1	0	0	0	90	0	1	0	1
-0.405	0	1	0	0	0	48	0	1	0	1
-0.182	0	0.917	0.083	0	0	46	0	1	0	1
-0.288	0	1	0	0	0	47	0	1	0	1
-0.182	0	0.833	0.083	0.083	0	52	0	1	0	1
0.080	1	0.75	0.25	0	0	64	0	1	0	1
-0.087	0	0.833	0.083	0	0.083	53	0	1	0	1
-0.182	1	0.917	0.083	0	0	55	0	1	0	1
-0.182	0	0.917	0	0	0.083	49	0	1	0	1
-0.182	0	0.917	0	0	0.083	65	0	1	0	1
-0.405	0	0.917	0	0.083	0	62	0	1	0	1
-0.405	0	1	0	0	0	59	0	1	0	1
-0.405	0	1	0	0	0	59	0	1	0	1
-0.405	2	1	0	0	0	60	0	1	0	1
-0.288	0	1	0	0	0	50	0	1	0	1
-0.182	1	0.917	0.083	0	0	74	0	1	0	1
-0.405	0	0.833	0.083	0.083	0	61	0	1	0	1
-0.288	1	0.917	0.083	0	0	70	0	1	0	1
-0.405	1	1	0	0	0	56	0	1	0	1
0.080	6	1	0	0	0	76	0	1	0	1
-0.288	0	0.833	0.083	0.083	0	67	0	1	0	1
-0.405	0	1	0	0	0	73	0	1	0	1
0.080	3	0.75	0.167	0.083	0	67	0	1	0	1
-0.405	0	1	0	0	0	66	0	1	0	1
-0.201	2	0.917	0	0	0.083	67	0	1	0	1
-0.288	1	0.917	0.083	0	0	70	0	1	0	1
-0.087	5	1	0	0	0	64	0	1	0	1
-0.182	1	0.917	0.083	0	0	60	0	1	0	1
-0.405	0	1	0	0	0	68	0	1	0	1
-0.182	3	1	0	0	0	69	0	1	0	1
-0.182	1	1	0	0	0	63	0	1	0	1
-0.288	0	0.833	0.167	0	0	57	0	1	0	1
-0.087	1	0.833	0.167	0	0	51	0	1	0	1
-0.182	2	0.917	0.083	0	0	89	0	1	0	1
-0.182	0	0.917	0.083	0	0	84	0	1	0	1
-0.182	1	0.917	0.083	0	0	82	0	1	0	1
-0.182	0	0.833	0.167	0	0	78	0	1	0	1
-0.182	1	1	0	0	0	65	0	1	0	1
-0.288	2	0.917	0.083	0	0	73	0	1	0	1
0.080	3	0.75	0.25	0	0	75	0	1	0	1
0.000	2	0.917	0.083	0	0	73	0	1	0	1
0.080	4	0.833	0.083	0.083	0	67	0	1	0	1

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
0.000	7	1	0	0	0	72	0	1	0	1
-0.288	0	0.917	0	0.083	0	75	0	1	0	1
-0.087	0	0.917	0	0	0.083	71	0	1	0	1
-0.288	2	1	0	0	0	91	0	1	0	1
-0.087	2	0.833	0.083	0.083	0	68	0	1	0	1
-0.288	0	0.917	0.083	0	0	54	0	1	0	1
-0.288	1	1	0	0	0	71	0	1	0	1
-0.087	0	0.833	0	0.083	0.083	68	0	1	0	1
-0.182	0	0.917	0	0.083	0	70	0	1	0	1
-0.182	4	1	0	0	0	50	0	1	0	1
-0.405	0	1	0	0	0	46	0	1	0	1
-0.288	0	1	0	0	0	84	0	1	0	1
-0.288	0	0.917	0.083	0	0	72	0	1	0	1
-0.288	0	0.917	0.083	0	0	92	0	1	0	1
-0.405	0	1	0	0	0	83	0	1	0	1
-0.405	0	0.917	0.083	0	0	75	0	1	0	1
-0.182	0	1	0	0	0	92	0	1	0	1
0.080	5	0.917	0.083	0	0	68	0	1	0	1
-0.405	1	1	0	0	0	67	0	1	0	1
-0.288	0	0.917	0.083	0	0	58	0	1	0	1
-0.405	1	1	0	0	0	70	0	1	0	1
-0.182	2	1	0	0	0	60	0	1	0	1
-0.182	0	0.917	0.083	0	0	66	0	1	0	1
-0.182	1	0.917	0.083	0	0	67	0	1	0	1
-0.182	0	0.75	0.167	0.083	0	60	0	1	0	1
-0.288	0	0.917	0.083	0	0	69	0	1	0	1
-0.288	1	1	0	0	0	71	0	1	0	1
-0.182	0	0.833	0.083	0	0.083	74	0	1	0	1
0.288	4	0.75	0.167	0	0.083	69	0	1	0	1
-0.182	4	1	0	0	0	65	0	1	0	1
-0.182	0	0.917	0.083	0	0	76	0	1	0	1
-0.405	3	0.917	0.083	0	0	72	0	1	0	1
-0.182	0	0.833	0.083	0.083	0	64	0	1	0	1
0.223	4	0.833	0.083	0.083	0	62	0	1	0	1
-0.087	0	0.917	0.083	0	0	72	0	1	0	1
-0.182	0	1	0	0	0	75	0	1	0	1
0.080	6	0.917	0.083	0	0	60	0	1	0	1
-0.288	0	0.917	0.083	0	0	69	0	1	0	1
0.154	2	0.833	0	0.083	0.083	47	0	1	0	1
-0.288	0	1	0	0	0	86	0	1	0	1
0.000	0	0.75	0.167	0.083	0	86	0	1	0	1
0.080	1	0.917	0.083	0	0	49	0	1	0	1
-0.182	1	0.917	0.083	0	0	44	0	1	0	1
-0.182	3	1	0	0	0	52	0	1	0	1
-0.288	0	1	0	0	0	60	0	1	0	1

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
-0.405	0	1	0	0	0	53	0	1	0	1
-0.087	0	0.917	0.083	0	0	75	0	1	0	1
-0.182	1	0.917	0	0	0.083	47	0	1	0	1
-0.288	0	1	0	0	0	60	0	1	0	1
-0.288	0	0.917	0	0	0.083	49	0	1	0	1
-0.182	0	0.917	0	0	0.083	64	0	1	0	1
-0.405	0	0.917	0.083	0	0	79	0	1	0	1
-0.405	0	1	0	0	0	66	0	1	0	1
-0.288	2	1	0	0	0	60	0	1	0	1
-0.405	0	1	0	0	0	54	0	1	0	1
-0.182	4	1	0	0	0	60	0	1	0	1
0.000	3	0.833	0.083	0	0.083	56	0	1	0	1
-0.288	0	0.917	0.083	0	0	57	0	1	0	1
-0.405	0	1	0	0	0	62	0	1	0	1
-0.087	2	1	0	0	0	57	0	1	0	1
-0.288	0	1	0	0	0	67	0	1	0	1
-0.288	0	0.917	0.083	0	0	56	0	1	0	1
-0.405	1	1	0	0	0	64	0	1	0	1
0.000	8	1	0	0	0	55	0	1	0	1
-0.087	4	1	0	0	0	64	0	1	0	1
0.080	0	0.833	0.083	0	0.083	61	0	1	0	1
-0.405	0	1	0	0	0	60	0	1	0	1
-0.405	0	1	0	0	0	69	0	1	0	1
-0.288	1	1	0	0	0	51	0	1	0	1
-0.087	3	1	0	0	0	77	0	1	0	1
-0.288	0	1	0	0	0	56	0	1	0	1
-0.182	3	1	0	0	0	66	0	1	0	1
-0.405	0	0.917	0	0	0.083	60	0	1	0	1
-0.087	2	0.917	0.083	0	0	77	0	1	0	1
-0.288	0	0.917	0.083	0	0	59	0	1	0	1
-0.182	0	0.75	0.083	0.083	0.083	50	0	1	0	1
-0.087	1	0.75	0.167	0.083	0	57	0	1	0	1
-0.087	2	0.917	0	0.083	0	55	0	1	0	1
-0.288	0	0.75	0.167	0.083	0	56	0	1	0	1
0.000	4	0.833	0.167	0	0	50	0	1	0	1
0.000	4	0.917	0	0.083	0	59	0	1	0	1
-0.087	0	0.917	0	0	0.083	52	0	1	0	1
-0.182	3	0.917	0.083	0	0	66	0	1	0	1
-0.182	2	0.917	0.083	0	0	50	0	1	0	1
-0.182	2	1	0	0	0	47	0	1	0	1
-0.182	2	0.833	0.083	0	0.083	49	0	1	0	1
-0.405	0	0.917	0	0	0.083	60	0	1	0	1
-0.288	0	0.833	0.167	0	0	67	0	1	0	1
0.460	6	0.833	0	0.083	0.083	50	0	1	0	1
-0.405	0	1	0	0	0	63	0	1	0	1

ln(h)	NC	TW	Car	LV	HV	Volume	Right	Shared	Through	Approach
0.080	2	0.833	0	0.083	0.083	57	0	1	0	1
-0.182	3	0.833	0.083	0.083	0	81	0	1	0	1
-0.288	0	0.917	0	0	0.083	50	0	1	0	1
-0.182	1	0.917	0.083	0	0	52	0	1	0	1

APPENDIX B: SUPPLEMENTARY REGRESSION RESULTS

Model Diagnostics

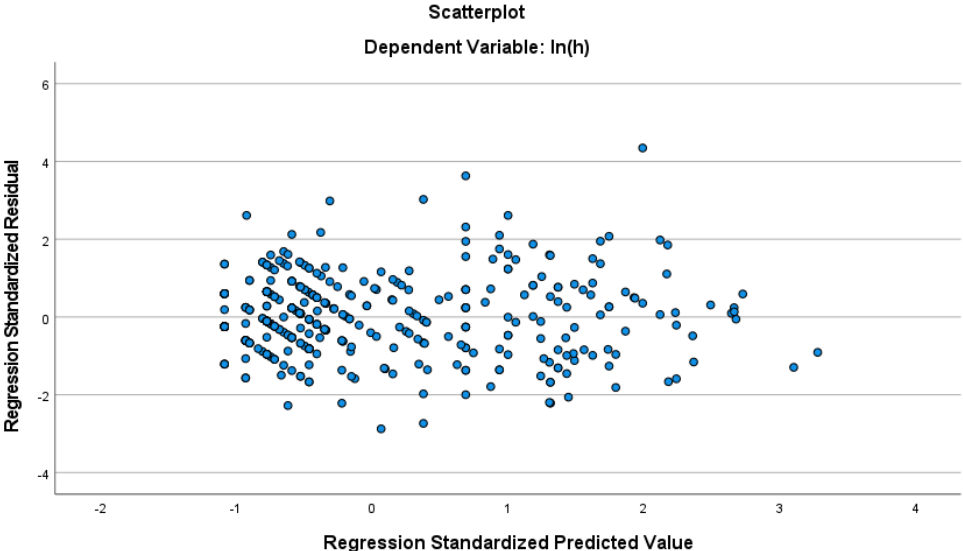


Figure B.1 Scatterplot of standardized residuals versus standardized predicted values

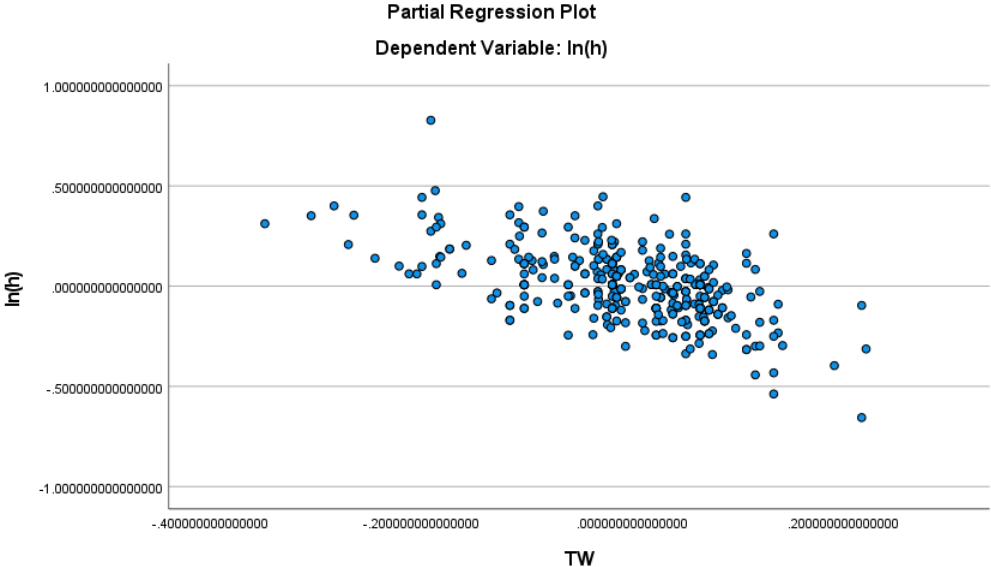


Figure B.2 Partial regression Plot between $\ln(h)$ and TW

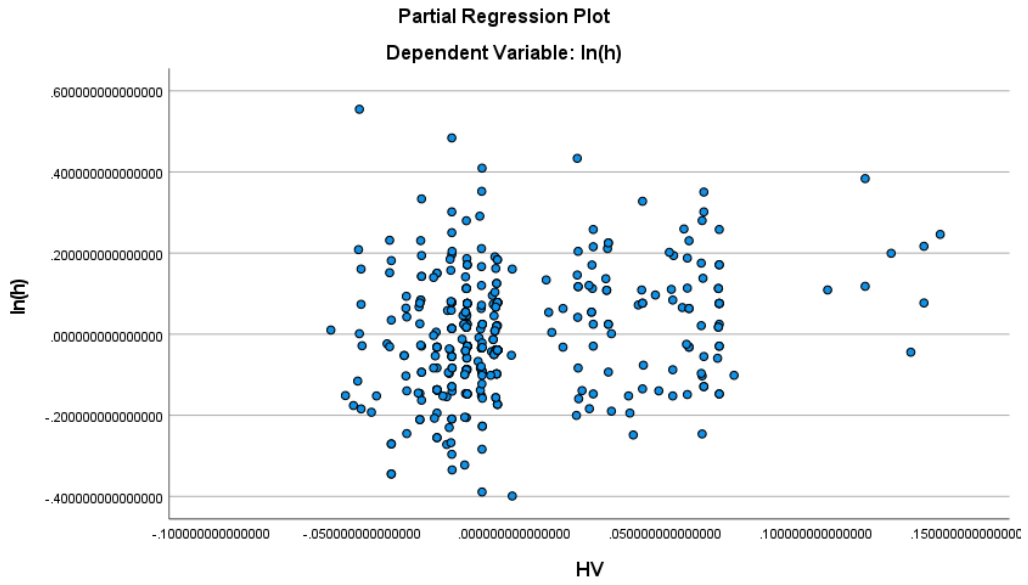


Figure B.3 Partial Regression Plot between $\ln(h)$ and HV

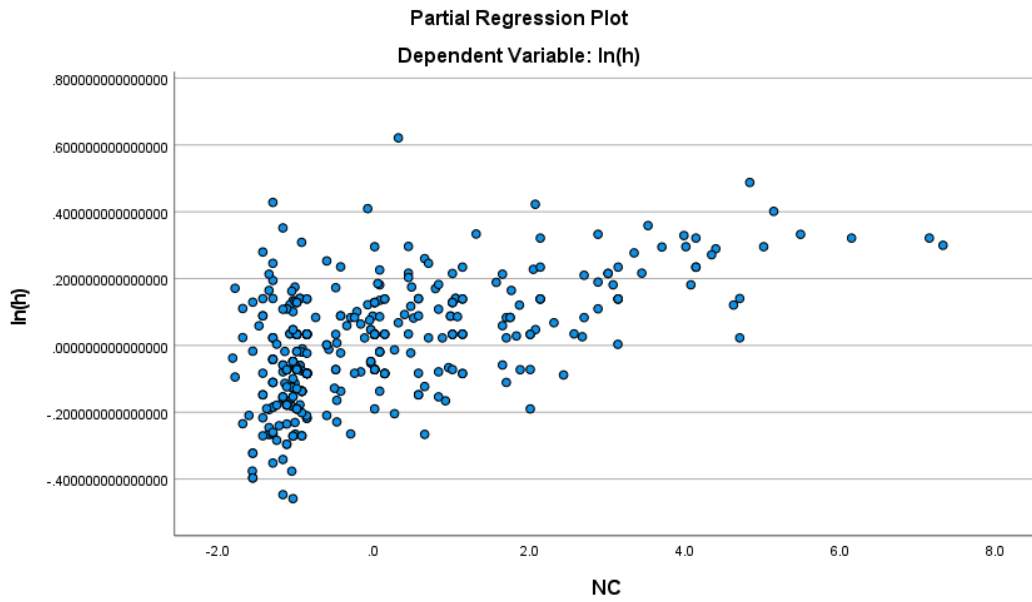


Figure B.4 Partial Regression Plot between $\ln(h)$ and NC

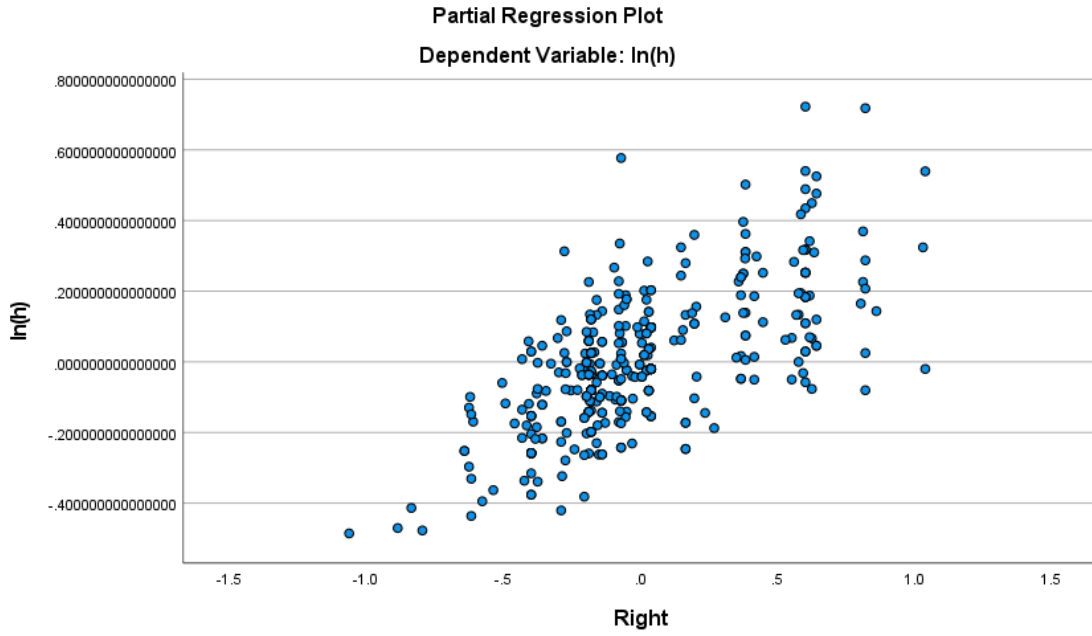


Figure B.5 Partial Regression Plot ln (h) and Right

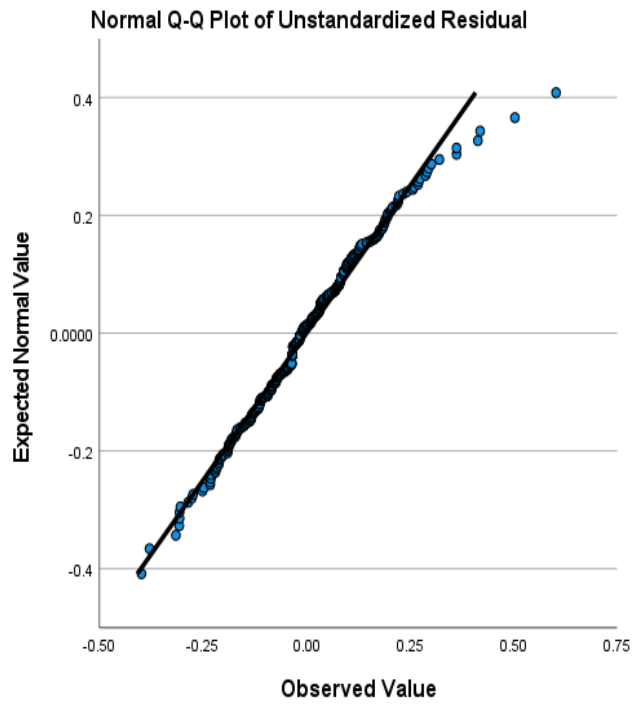


Figure B.6: Q-Q Plot of Unstandardized Residual

Holdout Validation Results:

Table B.2: Training Set Model Summary

R	R ²	Adj. R ²	Std. Error
0.915	0.836	0.834	0.138

Table B.3: ANOVA (Training dataset)

	Sum of Squares	df	Mean Square	F	Sig.
Regression	27.43	4	6.858	357.772	<.001
Residual	5.367	280	0.019		
Total	32.797	284			

Table B.4: Regression coefficient (Training dataset)

	B	Std. Error	Beta	t	Sig.
(Constant)	0.965	0.093		10.365	<.001
TW	-1.253	0.099	-0.428	-12.658	<.001
HV	0.966	0.243	0.104	3.98	<.001
NC	0.056	0.005	0.267	11.053	<.001
Right	0.357	0.024	0.481	15.068	<.001

Table B.5: Validation Set Statistics

Measure	Value
Correlation (R)	0.92
R ² on Validation Set	0.846
Sample Size	122
Significance	<0.001
Mean Error(MAE)	-0.0064
Mean Squared Error (MSE)	0.0195
RSME	0.1396