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VEHICLE MILES TRAVELLED AND TRAFFIC CONGESTION IN THE HARARE METROPOLITAN REGION

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Abstract:
Growing car ownership and congestion pose a threat to urban transportation sustainability in most urban areas globally. Harare Metropolitan Region has not been immune to traffic congestion due the influx of vehicles and the subsequent growth in private vehicle ownership. The study sought to determine the effect of vehicle miles travelled (VMT) on traffic congestion. A cross-section survey and a pragmatism research philosophy were utilized. The research focused on Harare Metropolitan Region households, urban planners, transportation planners, and motorists. The study's sample size was 384 people, chosen using convenience and purposive sampling techniques. Data was gathered from respondents using structured questionnaires and semi-structured interviews. To examine the validity of all the items included in the study, exploratory factor analysis (EFA) was utilized. Structural Equation Modeling (SEM) in Amos version 21 was used to test the study hypothesis. According to the study, VMT has a positive influence on traffic congestion. The study suggests that there is a need for actor-factor analysis, in which policies are developed by realistically connecting social actors from the top to the bottom. Furthermore, policymakers should enact policies and make appropriate investments that encourage people to drive less.

Key words:
Congestion, Transportation, Travel behaviour, Travel demand, Vehicle miles travelled

1 INTRODUCTION

Vehicle Miles Travelled (VMT) is regarded as the prime outcome of a combination of trip frequency, automobile ownership, mode choice, and trip length (Handy et al., 2012). According to Sardari et al., (2018), the rise in VMT increases roadway capacity where traffic congestion is present called "induced travel". In the same way, Handy et al., (2012) reiterates that the interruption of traffic movement is visible when demand for road capacity exceeds the present capacity of the road element, resulting in traffic congestion. According to United Nations (2014), the global vehicle ownership has risen from 0.85 billion in 2000 to 2.1 billion in 2016, resulting in increased exposure to traffic for most people. This is echoed by Moyano, et al., (2021) who noted that as the desire to use private vehicles the more the city becomes prone to congestion.

The decision to use private vehicles and the rejection of public transport is perceived as a natural consequence of a rational contrast amid costs and benefits various consumption possibilities. Mohan et al., (2017) emphasized that buses are more efficient but cars are faster and more comfortable. For instance, a bus in Sao Paulo, Brazil travels at 15 km per hour while the average speed of a car is 25 km per hour. This faster speed, along with the option to change routes and provision of door-to-door service, is more attractive to high-income commuters who place a higher value on their time and spend more on commuting Yang et al., (2020). Barrington-Leigh and Millard-Ball (2019) remarked that higher travel frequency increases the likelihood of traffic congestion. On the other hand, Levy, Buonocore and Von Stackelberg (2010) established that increases in VMT are associated with greater levels of traffic congestion, energy use and road accidents. Barrington-Leigh and Millard-Ball (2019) explained that growth of companies that provide mobility-as-a-service and the prospective introduction of self-directed vehicles further contribute to an increase in VMT as travel becomes convenient but burdensome, resulting in traffic congestion. Similarly, vehicle ownership is growing at a faster rate of between 15% and 20% per annum in developing countries. For example, Agyapong and Ojo (2018) observed that there were over 42.5 million registered vehicles in Africa. However, due to limited disposal incomes and high cost of new vehicles, second-hand cars dominate the African continent's retail automotive market with main imports coming from Japan, United States and the United Kingdom (Black and McLennan, 2016).

Owing to this high level of motorisation, modern cities have witnessed significant proportions of traffic congestion (Rajé, Tight & Pope, 2018). According to Olawole et al., (2011), in most developing countries, particularly in Nigeria, most of the vehicles on the roads are second-hand-vehicles popularly known as '*tokunbo*; imported from America and Europe. Such vehicles, left at the mercy of near illiterate mechanics and fake spare parts vendors, often break down and cause the already narrow road to further get choked, resulting in traffic congestion. Similarly, Mbara (2015) finds that the proliferation of second-hand vehicles has exacerbated traffic congestion in Harare. Statistics from the Central Vehicles Registry (CVR) show that from 2007 to the end of the first quarter of 2017, at least 510 275 second-hand vehicles have been imported into the country. According to Mbara and Pisa (2019), 70% of these vehicles are in Harare. However, this car-centric philosophy is failing to recognise the growing importance of different transportation modes such as urban rail system, bicycles, pedestrians and pushcarts; thus generating chaotic travel patterns (Mbara, 2015). Traffic congestion in Harare is observed though vehicle delays on major junctions and interchanges, vehicle queuing, traffic jam and accidents that characterise the morning, mid-afternoon and evening traffic peak periods (Munuhwa et al., 2020). It is important to note that conventional attempts such as road construction and widening to catch the worsening of congestion in Harare have proved to be expensive, unfeasible, and even short-sighted. Therefore, a different

arsenal will be needed in battling Harare's future congestion problems. This research looked into the link between vehicle miles travelled and traffic congestion in the Harare Metropolitan Region.

2 LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

This section presents literature review and development of hypothesis.

2.1 Vehicle Miles Travelled (VMT)

According to Tracy et al., (2011) VMT is the primary outcome of the combination of trip lengths, trip frequency and the mode choice. Similarly, Williams, et al., (2016) noted that VMT is an integrated product of many factors such as overall mobility levels, vehicle ownership and mode selection and trip length. Similarly, Rahane and Saharkar (2014) says the VMT is an essential measure of transportation planning, because it provides a measure of total travel, how travel changes and differences in travel in different areas. They also explained that the VMT is a leading measure of both personal and commercial travel demand. Since VMT measures the travel demand, it is therefore useful to determining where resources are most needed, and it is an important measure to monitor and forecasting travel demand (AbuLibdeh, 2017). It is asserted that increased travel on a roadway can result in slower speeds which in turn lead to delays Handy et al., 2012). Delays can waste fuel and both personal and commercial time, each generating associated costs. As a measure of the trip and distance, VMT can help planners to calculate out-of-pocket traveller cost savings and other benefits such as time savings where improvements are implemented (Koźlak & Wach, 2018). This study operationalizes vehicle miles travelled as in terms of trip frequency, mode choice, vehicle ownership and trip distance. Any change in urban travel patterns positively impacts traffic circulation.

2.2 Traffic Congestion

According to Talukdar (2013) traffic congestion does not have a universally accepted definition. As a result, scholars have provided distinctive definitions to what they hypothesise as traffic congestion (Ndatho, 2018). From an engineering perspective, traffic congestion is viewed as a mismatch between demand for road capacity and infrastructure supply (Federal Highway Administration, 2017). In that respect, traffic congestion is seen in terms of vehicle concentration, road capacity and speed. Afrin and Yodo (2020) observed that when there is traffic congestion, traffic speeds will decrease when traffic flow is added to reach the capacity. According to Fesler (2013), traffic congestion is experienced when travel demand is high enough such that the interaction between vehicles slows the speed of the traffic flow and is manifested by slower speeds, longer travel times and increased lining up and tailgating. Likewise, the Chakrabartty & Gupta (2014) relates traffic congestion to the slow movement in a roadway road way. The existing literature on traffic planning offers a diverse but inconsistent set of congestion indicators (Moyano, 2021). A plausible explanation to this is that it could be the lack of a universally agreed definition of traffic congestion. Fiedler, Čáp and Čertický (2017) as well as Ewing, Tian and Lyons (2018) assert that traffic congestion can be measured using traffic volume, commuting time and speed while Sardari (2018) noted that traffic congestion can be measured using statistical ratios. The study considers traffic congestion to be associated with increases in travel time, reduction in travel speeds, delays and difficulties in vehicle manoeuvrability.

2.3 Development of hypothesis

Findings from previous studies show a general consensus that VMT has a positive effect on traffic congestion. Ewing and Cervero (2001) noted that the increasing use of private vehicles results in demand for parking and road capacity. The desire to use private vehicles increases more as the city is prone to traffic congestion Mohan et al., (2017). In like a manner, Schrank and Lomax (2005) remarked that higher travel frequency increases the likelihood of traffic congestion. Using disaggregated 2009 NHTS data, De Leaniz et al., (2016) found an inverse relationship between VMT and traffic congestion around household home locations. On the other hand, Barrington-Leigh and Millard-Ball (2019) established that increases in VMT are associated with higher levels of traffic congestion, energy consumption and road crashes. Levy et al., (2010) explained that the growth of companies that provide mobility-as-a-service and the prospective introduction of self-directed vehicles further contribute to an increase in VMT as travel becomes convenient but burdensome, resulting in traffic congestion. It is expected that an increase in the number of trips generated using private vehicles destruct the free flow of traffic. Therefore it is posited that:

H_1: Vehicle miles travelled has a positive effect on traffic congestion

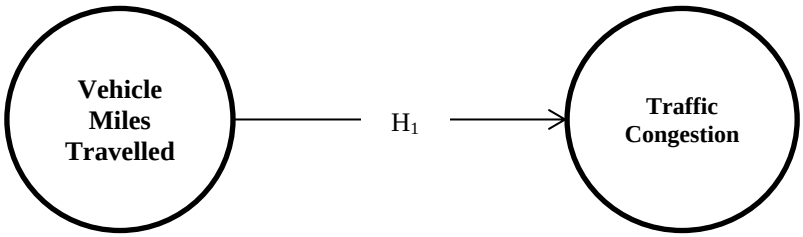

Fig 1: *Research Model*
Source: Researchers (2021)

3 METHODS AND METHODOLOGY

A cross-section survey and a pragmatism research philosophy were utilized. The target population was comprised of households, urban planners, transportation planners and motorists in the Harare Metropolitan Region. The sample size for the research was 384 people obtained using the Krejcie and Morgan (1970) formula. Respondents were chosen using convenience and purposive sampling. Data was collected from respondents using structured questionnaires and semi-structured interviews. The structured questionnaire was categorised into three sections, namely demographic characteristics of respondents, vehicle miles traveled (VMT) and traffic congestion (TC). Four items were used to measure VMT. The items were adapted from Tracy et al., (2011); Ewing and Cervero (2001). On the other hand, TC was measured using four items adapted from (Fesler, 2013; Afrin & Yodo, 2020; Schrank & Lomax, 2005). The measures used were modified in the context of this study. All items were measured on a five-point Likert scale (5-Strongly Agree, 4-Agree, 3-Not sure, 2-Disagree and 1-Strongly Disagree). The quantitative responses obtained were analysed using statistical package for social scientist (SPSS) version 20. In addition, AMOS version 21 was used to perform confirmatory factor analysis (CFA) and structural equation modeling (SEM) De Leaniz et al., (2016). Before testing the research hypothesis, data were assessed for convergent and discriminant validity. Hypotheses for this study were tested using Structural Equation Modelling (SEM) in Amos version 21.

4 RESULTS AND DISCUSSION

According to Pallant (2011), the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) should be performed to confirm that the requirements for factor analysis are met. A KMO of 0.722, an approximate Chi-square of 296.520, and degrees of freedom [df] =253; $p<0.001$ were registered indicating that the sample was acceptable and thus allowed explanatory factor analysis (EFA). Ref Field (2009) suggested that the lower expected threshold for KMO test should be 0.5 with high values more desirable. Atalay et al., (2013) pointed out that for a measure of multivariate normality that is the Bartlett's test the p-value should be significant at $p<0.05$. Table 1 shows the factor loadings.

Tab. 1 *Construct, item description and factor loadings*

Construct	Item description	Factor loadings
Vehicle Miles Travelled (VMT)	People travel frequently	.723
	People prefer private vehicles to public transport	.745
	Vehicle ownership has increased	.732
	People travel longer distances to the central business district	.673
	Travel time has increased	.705
Traffic congestion (TC)	Travel speeds for vehicles have reduced	.745
	There are many delays at intersections	.603
	There are difficulties in vehicle manoeuvrability	.671

Source: Survey Data (2021)

A total variance explained of 68.857% was obtained. This was above the acceptable limit of 60% (McQuitty, 2004). The researchers tested research hypothesis after identifying factors underlying the constructs. This was done to determine the nature and strength of relationship that exist between study variables. The variables of the study were vehicle miles travelled (VMT) and traffic congestion (TC). The structural model was estimated using the Maximum Likelihood Estimation (MLE) as suggested by Bagozzi and Yi, 1988). The SEM was opted because it is able to determine relationships between variables and suggest a general fit between the research model and the observed data (Chang et al., 2010). The value of Adjusted Goodness of fit index (AGFI), Goodness of fit index (GFI), Tucker-Lewis Index (TLI), Normed fit index (NFI) and Comparative fit index (CFI) indicate a good fit when values are close to 1 Fornell and Larcker (1981), while for Root mean square error of approximation (RMSEA) values must be in the range of 0.05 to 0.10 for a model to be approved (Monteiro & Soares, 2017).

Testing research hypothesis

Structural equation was done in AMOS version 21 test the structural relationships in Fig 1(H_1). The structural model demonstrated good model fit indices (CMIN/DF = 3.178; GFI =.892; AGFI =.904; NFI =.937; TLI =.841; CFI =.812 and RMSEA =.043). Results are shown on Table 2.

Tab. 2 *Hypothesis Testing*

Hypotheses	Hypothesized Relationship	SRW	CR	Remark
H_1	Vehicle Miles Travelled → Traffic Congestion	1.227	21.944***	Supported

Source: Survey Data (2021)

The study's findings on Tab. 2 confirm that vehicle miles travelled has a positive relationship with traffic congestion. This implies that the vehicle ownership, trip lengths and travel frequency have increased drastically in Harare Metropolitan region. Vehicle miles travelled is widely viewed as the single best barometer that reflects the nature of urban travel patterns. It is the primary outcome of the combination of trip lengths, trip frequencies and mode choice Handy et al., (2012). An increase in the number of vehicles in Harare has destructed the free flow of traffic in the central business district. The study publicized that vehicle ownership has increased. This finding is consistent with Mbara and Pisa (2019) who observed that traffic congestion in Harare is caused by an inflow of used automobiles. In addition, this corroborates with data from the Central Vehicle Registry, which reveals that between 2007 and the end of the first quarter of 2017, at least 510 275 used automobiles were imported into the nation. The rise in car use and ownership can be attributed to an increase in people's real disposable personal income under the multi-currency system.

The effects of higher income on passenger vehicle travel are manifested in higher levels of automobile ownership and growth in the proportion of households owning multiple vehicles. In turn, these trends not only increase trips and travel, but also reduce the number of trips made by transit or walking and increase the number of discretionary trips. Furthermore, (Christiansen & Loftsgarden, 2011) discovered that access to private or reserved parking triples the likelihood of car ownership. This implies that the increase in the level of car ownership Harare may have been exacerbated by access to home parking. A number of empirical studies have agreed that the desire to use personal vehicles increases the more the city is prone to traffic congestion. Findings from the study revealed that people travel longer distances from their places of residence to the central business district. This implies that most people in Harare Metropolitan region are auto-dependent. This is in agreement with findings of Goel and Mohan (2020) who found that the spatial distribution in daily activities and increasing rate of car ownership are central to increases in travelled distances and car dependency. Another plausible explanation for the high rate of VMT is the higher proportion of the driving-age population that became licensed. In Zimbabwe, the legal age of driving is 16. This means that as population density per square mile increases, so does vehicle travel intensity in terms of vehicle miles per square mile. The findings from this study also established that people travel frequently using private vehicles. This ties in well with findings of Páez et al., (2007) who found that household auto and license ownership increases the frequency for travel and consequently VMT. In addition, changes in fuel prices may have significant influence on VMT, thus creating a gap for further research. Furthermore, Song et al., (2017) discovered a similar pattern of findings when they discovered that car ownership is a substantial contribution to urban traffic congestion.

5 CONCLUSIONS AND IMPLICATIONS

The research indicates that the rapid growth of Harare, along with an increase in vehicle ownership, has resulted in a fundamental shift in traffic conditions. This implies that traffic congestion in the Harare Metropolitan Region is a product of increased vehicle trip frequency, increased journey distance, and a desire to use motor vehicles. VMT of households and individuals can be managed in a progressive manner by the development of policies that practically connect the social actors from the top to the bottom. Policymakers should not hesitate to make prudent investments that encourage less driving. This includes increasing the legal driving age from 16 to 21 years, as well as raising taxes and pricing on fuel and vehicle imports. Harare City fathers should implement pricing related strategies such as fuel taxes policies and tolls. These strategies have the potential to reduce VMT per person while increasing government income.

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