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The Behaviour of Personal Motorists and the Costs of Traffic Congestion in Nairobi, Kenya

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Abstract: ***Globally, traffic congestion is a wasteful phenomenon where its effects include delayed travel times, reduced productivity and business opportunities, accidents, frustrations, stress and pollution. This study analyzed the behavior and characteristics of personal motorists and estimated the costs of excess fuel and time lost due to traffic congestion in Nairobi, Kenya. Identification of study variables relied on theories and principles from welfare economics and studies on traffic congestion. Data was collected through a well designed questionnaire administered to the city's motorists, interviews with key informants, observations and secondary data sources. Descriptive statistics, mathematical computations, econometrics and counter factual analysis were used to analyze the data. Results showed that the city's motorists understood the problem of traffic congestion and revealed varied perceptions on related issues such as the public transport system in the city. The total social cost of traffic congestion in the city was estimated as Ksh 146.5 billion and Ksh 16.7 billion annually in terms of delays and wasted fuel respectively (2011 prices). The study concludes that effective management of traffic congestion in Nairobi should actively involve the city's motorists including designation of the problem as a matter of national priority to enhance attention on it in terms of budgetary allocation.***

Keywords: Traffic congestion, behavior, characteristics, costs, Kenya**.**

1. Introduction

Congestion involves queuing, slower speeds and increased travel times, which impose costs on the economy and generate multiple impacts on urban regions and their inhabitants. According to Nairobi Metro 2030 Strategy transport forms a key component of creating a competitive business environment as well as means through which various socio-economic and environmental objectives can be achieved. Congestion disrupts the conduct of business within any urban area. Sao Paulo, Brazil has the world's worst traffic jams according to Time Magazine (2006).

Traffic congestion may be classified as recurrent (Glicken, 2000) – generally the consequence of factors that act regularly or periodically on the transportation system, such as daily commuting or weekend trips. Non-recurrent congestion on the other hand is the effect of unexpected, unplanned or large events (e.g. road works, crashes, special events and so on) that affect parts of the transportation system more or less randomly and, as such, cannot be easily predicted (OECD, 2002). Congestion has a range of indirect impacts (OECD, 2004). According to Transport Canada,(2006), such impacts may include political and the marginal environmental and resource impacts of congestion, impacts on quality of life, stress, safety. Impacts on non-vehicular road space users such as the users of sidewalks and road frontage properties have also been included.

Governments all over the world understand that measuring congestion is a necessary step in order to deliver better congestion outcomes, however, the subject is shrouded in lots of controversies (Transport Canada, 2006). There is no single, broadly accepted definition of traffic congestion according to Organization for Economic Co-operation and Development (OECD) and European Conference of Transport Ministers (ECMT) report of 2007 including methodology of estimating the related costs and benefits associated with it. The causes, nature and frequency of traffic congestion may therefore vary between areas, cities and roads within a city due to the differences in the physical transportation infrastructure and the perceptions of the area's people on the problem.

Nairobi is the capital city of Kenya and also the capital of the Administrative area of Nairobi. It has the highest urban population in East Africa, estimated at between 3 and 4 million (Wikipedia, 2011). It is home to thousands of Kenyan businesses and over 100 major international companies and organizations, including the United Nations Environmental Programme (UNEP). Nairobi is an established hub for business and culture. It is estimated that the vehicle population in Nairobi stands at above 300,000 vehicles in the year 2008 and has been increasing at 5,000 vehicles per month, (Ministry of Roads 2013).

Traffic jam is therefore a major problem in Nairobi with a debilitating effect on the quality of life of people. Drivers and pedestrians in the city continuously suffer the negative impacts of traffic jams which include delays, lost opportunities, higher costs of living, increased accidents, reduced competitiveness, frustrations and pollution. Transport authorities in Nairobi must manage the problem to acceptable levels for drivers and residents in the city to realize the benefits that come with an effective and efficient transportation system, Irung'u (2007).

The specific objectives of the study was to analyze the behavior, characteristics of personal motorists and estimated the costs of excess fuel and time lost due to traffic congestion in Nairobi, Kenya. Some of the study limitations included the lack of consensus on common definition of congestion and a framework to measure the costs and benefits associated with the problem.

2. Methodology

While relying on stakeholder analysis theories, Steve, (2001) including other statistics that personal vehicles amount for about 80% of the vehicles entering Nairobi's CBD (Irungu, 2007), personal motorists in the city were mapped as influential stakeholders in determination of strategic decongestion solutions. Influential stakeholders are people who have power over a project. They may control what decisions are made or how it is implemented, or exert some other influence which affects the project negatively. They may be able to coerce or persuade others into making decisions about it, UNEP (1998).

The study therefore hypothesized that understanding the perceptions of personal motorists in the city regarding traffic congestion would be the basis for determining a lasting solution to this problem. The study therefore sought for various perceptions from the motorists about traffic congestion in the city as follows:

- Whether they perceive traffic congestion as a problem or not.
- The type of roads they use into the CBD.
- The problems they associate with traffic congestion.
- The attributes of the personal car or why they prefer using their personal cars.
- Their perceptions about problems with public transport in the city; and,
- Perceptions on their wiliness to leave their cars at home if public transport is improved to their tastes.

The study devised an operational definition of traffic congestion based on existing theories and literature on the subject to facilitate estimation of these costs and benefits. A model was then developed to faciltate estimation of delays and excess fuel consumption as a result of traffic congestion.

2.1 Data Collection

Data on the motorists' perceptions and the costs related to traffic congestion was collected through a well designed questionnaire and secondary sources. Data was also collected through the researcher's own observations.

2.2 Estimating Costs of Traffic Congestion

It is very difficult to estimate an event which one cannot define. In that regard, and based on the fact that there isn't an agreed universal definition of traffic congestion, OECD (2007), the study devised the following definition to estimate costs of time lost and excess fuel consumed as a result of recurrent traffic congestion:

"Traffic Congestion is the condition on a road for a period of not less than 1 hour where several willing and able transiting vehicles covering a distance of at least 1 km and spaced about 1 meter from each other are either stationary or move at less than 20 km/hr due to lack of space ahead", (Chama, 2011).

The definition is mainly based on the Engineering approach which defines congestion in terms of the direct and physical characteristics of congestion linking vehicle flow/traffic speed to road capacity (measured as vehicles per hour), VTPI (2005). However, during the empirical processes of estimating these costs, perceptions and expectations of the road users on the performance of the road systems were equally considered. As is argued in literature cited above, these two aspects cannot be separated.

The study estimated costs associated with delay and excess fuel consumption related to recurrent congestion, that is, costs as a result of congestion caused by regular or periodical factors, mainly lack of adequate space to accommodate the vehicles demanding space. Costs related to congestion caused by non-recurrent factors such as accidents, bad weather, traffic police interruptions, etc were not estimated. On the day of data collection if such causes did occur the congestion on that particular day was considered as normal (regular) recurrent congestion. The rationale for this decision is that non-recurrent causes of traffic congestion are short-lived and their costs may be misleading if they are relied upon on matters of policy on the subject.

2.3 Cost of Time Lost (Delay)

Cost of delay meant measurement of all traffic delay in relation to "free-flow" or unimpeded conditions, an approach used by the Texas Transportation Institute (TTI). Free flow is defined as the condition of traffic when there is no interference from other vehicles on the road and drivers can move freely at the speed they wish. Though free-flow speed may seem an impractical policy ideal particularly in cities, motorists in Nairobi witness free-flow speeds on the same congested roads at certain hours of the day. This was the rationale for using "free-flow speed" as the standard against which delay costs due to traffic congestion were measured.

The delays were those that occurred during peak hours only; week days; and, in the morning when people were travelling to the CBD. Peak hours were those that the researcher was informed by Traffic Police since they were key informants on matters of traffic congestion – virtually all the main roads to the CBD are manned by Traffic Police during peak time to manage traffic congestion.

One other important scenario was that the survey was carried out when schools were opened because it is a general perception by people in Nairobi that traffic congestion is severe during this period.

The roads studied were those that enter the CBD only, that is, Mombasa Road, Langatta Road, Jogoo Road, Ngong Road and Waiyaki Way/Uhuru Highway. Thika Road was excluded due to the ongoing construction. The points where congestion starts building during peak hours in these roads was the starting point of measuring the time taken to enter the CBD, for instance, The Army Barracks to Agip (Langata Road); Ngong Hills Hotel to GPO (Ngong Road); Posta to Commercial (Jogoo Road); and, Westlands Round-About to Commercial (Waiyaki Way/Uhuru Highway). These points were identified through key informants, the Traffic Police,

regular users of those roads and by the researcher through observations.

Practically, the measurement entailed starting the journey at the identified points at the exact hour of peak and travel to the CBD then record the number of minutes/hours it has taken. The entry point to the CBD was also identified. This was not to be a problem because the map of the CBD was available. Two week's average was the time taken to enter the CBD. A free-flow speed of 80km/hr was considered as the standard and a monthly earning for workers in Nairobi was considered as the value of time in the city. The rest of the computations were basically mathematical.

Multiplying the delayed time (minutes) by the number of week days in a year give us the total time lost by one motorist in one year. Multiplying this by the value of time in Nairobi will give us the cost of delay in a year for one motorist. Multiplying this by the number of motorists in the city gives the total social cost of delay as a result of traffic congestion.

2.4 Cost of Excess Fuel Consumed

The study applied a simplified fuel calculation model without distinction by vehicle type, that is, taking all motor vehicles in the model assignment as a single class of vehicles. Though different vehicle types have varying fuel consumption rates, this would not limit the workings of the model as the applied fuel consumption rates did not require that distinction – the distance covered by the vehicle was the key determinant in the model. The fuel consumption rates applied were those developed by the Virginia Polytechnic Institute (VIP) which constitutes the most recent and state-of-the-art fuel consumption and emissions models categorized as either macroscopic or microscopic which notes that fuel consumption rates vary depending on the type of vehicle (gasoline-powered automobile versus diesel truck) and driving environment (urban versus freeway travel, un-congested versus congested travel).

The rates were derived for various service levels from on-road vehicle testing of light duty gasoline-powered vehicles only. These rates were given as ml/veh-km for an approximate average speed (LOS). For example, for Freeway LOS-G for an approximate of average speed of 20km/h, the fuel consumption rate is 113.13 ml/veh-km. These data indicate that fuel consumption tends to increase with increased congestion (optimal fuel consumption is seen to be achieved between 85km/h and 105km/h).

The study used these rates to calculate the costs of wasted fuel because Kenya does not have this data while assuming that they were representative of the Kenyan scenario. The study's results are therefore reported based on the scenario of lack of our own data in the country which is equally a policy statement to the relevant government agencies that there are missing gaps which need to be filled.

From the survey data on delay above, since the distance from the point of measurement and time it took to enter the CBD is known, it is without difficulty to calculate the average speed at which the vehicle was moving. Once this is available, the respective rate to use as per the foreign published data mentioned above shall be identified. Using the rate in ml/veh-km and the distance the wasted fuel as the product of the distance and the quantity in ml of fuel (distance x ml of fuel) shall be calculated. Given that during traffic jam the speed is very low or the vehicles are stationary and within the study's definition of traffic congestion stated above, the rate of 20km/hr was used for the necessary computations. The average of the quantity of wasted fuel of the morning trips was used. Multiplying that quantity by the number of week days in a year we get the fuel wasted by one vehicle annually.

Multiplying that annual figure by the estimated number of vehicles entering the CBD everyday (since all these vehicles entering the city face the jam) we get the total fuel wasted by all vehicles in the city. Multiplying this by the average unit price of fuel (gasoline) in Nairobi in the year 2011 without taxes because we are looking at social costs and not private costs, we get the cost of fuel wasted by vehicles annually in Nairobi.

2.5 Location of Study

The study was conducted in Nairobi city, Kenya.

2.6 Sampling/Population of the Study

Questionnaires were administered randomly to 150 personal motorists who lived and worked in Nairobi targeted at car parks or in their offices.

3. Research Findings

The city's motorists were interviewed through a questionnaire adequately designed to solicit for their views on the problem. About 59% and 41% of the respondents were male and female, respectively. The study results therefore reflect adequately the views of both gender categories. Gender (male or female) was also considered as one of the study variables influencing the motorists' WTP bids in the CVM survey below.

Motorists were asked about the roads they use in their way to the CBD. These were the roads that are considered to be the most congested in Nairobi. The responses are shown in table 3.1.

Table 3.1: Mainly used Roads by Motorists in Nairobi

	Percentage (%) Yes
Thika Road	20
Mombasa Road	20
Jogoo Road	17
Lang'ata Road	33
Ngong Road	14
State House Road	6
Uhuru Highway/Waiyaki Way	17
Other Roads	18
TOTAL	145%
MEAN	145/8 = 18%

(Source: Author, 2011)

Seven roads linking the CBD with Nairobi's residential were identified as the mainly congested roads and from a total of 150 motorists that were interviewed, an average of 18% (No. 27) respondents were allocated to each road, as shown above. The total of 145% is explained by the fact that some motorists use about two or three roads before entering the CBD. For example, a motorist from Ongatta Rongai will use Lan'gatta Road then Uhuru Highway before he enters the CBD. It is therefore imperative to note that all the roads that are considered traffic congested were equally represented in the study. 92% of respondents said traffic congestion was a problem to them while 8% said it was not. Though the question is rather psychological, it was necessary in indicating expected responses to the WTP question or the desire for the proposed traffic decongestion program in the CVM survey.

3.1 Motorists' preferences on Personal Cars

About 47% of the respondents consider cars as a demonstration of one's social status while the rest (53%) did not. Traditionally, cars are a demonstration of affluence, that is, the status that one has a lot of money, possessions and wealth (Liza 2007).

Results in Figure 3.1 shows that the main reasons for using private vehicles were convenience and flexibility. Irungu (2007) observed that 54% of motorists in Nairobi would not switch to public transport system even if it was introduced with faster speed where resistance to change was exhibited by hate of walking and waiting, having baggage, uncomfortable public transport and security fears.

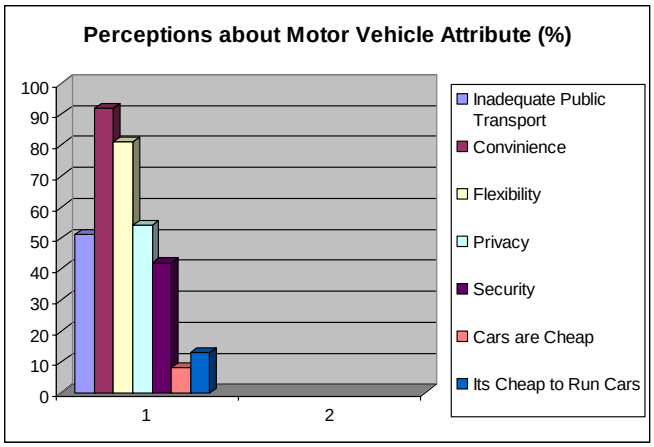

Figure 3.1: Perceptions about Car Attributes (%) (Source: Author, 2011).

3.2 Encouraging use of Public Transport

The perceptions that motorists fronted regarding inadequacy of the public transportation system in the city were as shown in figure 3.2.

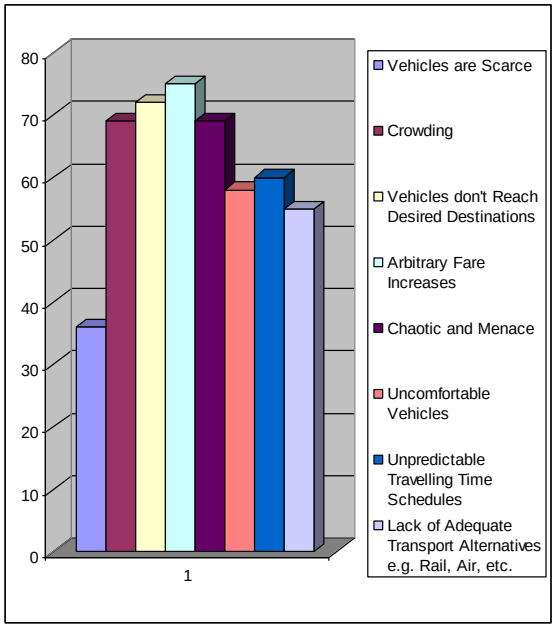

Figure 3.2: Perceptions on Problems with Public Transport (%) (Source: Author, 2011)

With the exception of 36% of the motorists who said scarcity of vehicles is not a problem as regards public transportation, majority of them cited crowding (69%); vehicles not reaching desired destinations (72%); arbitrary fare increases (75%); chaos and menace (69%); lack of comfort (58%); unpredictability of traveling time schedules (60%); and, lack of adequate transportation alternatives such rail and air (55%), as key problems related to the public transportation system in the city.

3.3 Travel Delay Costs (Extra Time Spent in Congestion)

The following Table 3.3 presents a summary of the data that was used to estimate the cost of extra time spent due to congestion in Nairobi during peak hour.

Table 3.3: Estimates of Motorists' Travel Data in Nairobi

No.	Item Description	Data
1.	Daily Average Time Spent to enter CBD during peak time.	49 minutes.
2.	Average Distance from Designated Measurement Point to CBD.	8 Kilometers.
3.	Allowed Posted Speed	80 km/hr
4.	Value of Time in Nairobi (Average Earnings per Hour in 2011 as per Government Statistics).	Ksh 1,618.74
5.	Estimated Number of Vehicles entering the CBD Everyday.	500,000
6.	Number of Working Days in 2011.	252 Days

(Source: Author, 2011)

From the above data, the cost of travel delay is computed as follows:

- The average distance of 8 km from the designated points of measurement to the CBD would take 0.1 hours (6 minutes) if a vehicle travels at free flow while traveling at the city's allowed speed of 80 km/hr;
- The extra time spent in congestion every day is therefore the difference between the daily average time spent to enter the CBD from the designated points (49 minutes)

and the time it would take while traveling at free flow from those points (6 minutes), that is, 43 minutes;
- In the year 2011, the number of minutes wasted due to congestion for the 252 working days was 10,836 minutes (252 x 43), equivalent to 181 hours annually;
- A single traveler therefore losses earnings worth Ksh 292,991.94 annually (181 x 1618.74) in Nairobi due to traffic congestion;
- The total social cost in terms of the number of vehicles that are estimated to enter the CBD everyday is Ksh 146,495,970,000 equivalent to $1,635,912,562.80 (in 2011 dollars – 1$ = Ksh 89).

The results are conservative because the cost would be higher if the total figures for workers in the city, value of time in private sector was used to compute it and if it is translated to the whole country's economy. However, the results indicate that delay costs are the largest component of total congestion costs at about 89.9%. A study in Canada estimated that the total delay cost of congestion (in 2002 dollars) for eight cities in the country (Vancouver, Edmonton, Calgary, Winnipeg, Hamilton, Toronto, Ottawa, Montreal and Quebec) was $2.7 billion which was 90% of total congestion cost including cost of excess fuel. The figure of $1,635,912,562.80 for one city (Nairobi) is very large compared to a total $2.7 billion for eight cities in Canada.

3.4 Cost of Wasted Fuel (for speeds of less than 20km/hr)

Table 3.4 presents a summary of the data that was used to estimate the cost of extra fuel consumed due to congestion in Nairobi during peak hour (Appendix D):

Table 3.4: Extra Fuel Consumed by Motorists

No.	Item Description	Data
1.	Fuel consumption (ml/veh-km) for Arterial LOS road driving at 20km/hr (Virginia Tech Energy and Emission Model).	141.59 ml.
2.	Average Distance from Designated Measurement Point to CBD.	8 Kilometers.
3.	Fuel consumption (ml/veh-km) at Freeway High-Speed driving at 105 km/hr (Virginia Tech Energy and Emission Model).	65.22 ml.
4.	Estimated Number of Vehicles entering the CBD Everyday.	500,000 Cars
5.	Number of Working Days in 2011.	252 Days
6.	Average Price of Fuel (combined, Petrol and Diesel) in 2011.	Ksh 108.28

(Source: Author, 2011)

From the above data, the cost of excess fuel due to congestion is computed as follows:
- A vehicle moving from the designated point of measurement to the CBD, a distance of 8 km and moving at a speed of 20 km/hr during traffic congestion would consume 1,132.72 ml of fuel;
- At freeway high speed the vehicle would consume 521.76 ml of fuel from the designated point of measurement to the CBD;
- The excess fuel used by the vehicle as a result of traffic jam is therefore 1,132.72 ml less 521.76 ml which is equivalent to 610.96 ml, the wasted fuel by one vehicle per day (one way);
- For 252 working days in 2011, one vehicle wasted 153,961.92 ml due to traffic congestion, equivalent 153.96 liters annually;
- At an average price of Ksh 108.28 for a liter of fuel, one vehicle wasted fuel worth Ksh 16,670.79 annually;
- The social cost of wasted fuel for an estimated 500,000 vehicles entering the CBD, is Ksh 8,335,395,000 which doubles to Ksh 16,670,790,000 return equivalent to $186,161,809 (in 2011 dollars).

The cost of wasted fuel is about 10% of the total (delay and wasted fuel) cost of traffic congestion in Nairobi. The results are consistent with the Canadian study which observed that cost of wasted fuel made up 7% of the total cost of traffic congestion for eight cities in the country (Vancouver, Edmonton, Calgary, Winnipeg, Hamilton, Toronto, Ottawa, Montreal and Quebec) estimated at about $200 million (in 2002 dollars). Inflationary causes explain why the Nairobi figure ($186,161,809) is substantially large against a total of the eight Canadian cities.

4. Conclusion

The city's motorists raised various issues regarding traffic congestion in the city. Traffic congestion affected their quality of life where motorists cited wastage in productive man hours; general stress and frustrations; increased fuel costs; increased maintenance costs of the car; pollution of the environment, amongst others as the problems they suffer from traffic congestion. The solution to decongesting the city must closely involve the city's personal motorists as 65% admitted that they are the cause of the problem. However, many of them (53%) did not see the personal car as a status symbol but preferred it majorly due to its convenience and flexibility – this indicates an opportunity towards the efforts aimed at mitigating the problem.

Traffic congestion was observed as a wasteful phenomenon where on average each motorist in the city wastes 49 minutes (one-way) everyday due to traffic jam costing them Ksh 146.5 billion annually of worth of useful time. Motorists also consume an extra 154 liters annually of fuel as a result of traffic congestion costing them Ksh 16.7 billion each year of wasted fuel. Traffic congestion in Nairobi should now be designated as a matter of national priority to enhance attention on it in terms of budgetary allocation as it is a wasteful phenomenon.

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