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Public transportation in the DMQ by geography and incidence

Transportación pública en el DMQ según su geografía y su incidencia

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Abstract

Excessive traffic and the need to move around have created social, infrastructure, time and coverage problems due to the value currently provided by urban transportation. The objective of this study is to analyze the incidence of public transportation in the DMQ according to the variable considered geographically and the way in which it affects fuel consumption. Through a descriptive analysis of the factors that affect fuel consumption, data was collected from three transportation routes, each with different geographic characteristics to determine an average consumption in each route. The fuel consumption of route 3 (Ofelia/Marín) was determined to be adequate according to the study, where route 3, with its geographic conditions and greater distance compared to the others, has an ideal driving performance close to constant speeds. It is concluded that fuel consumption is affected by the type of driving of the vehicle as well as the geographic conditions present in the DMQ, however, the percentage of profit of each operator affects citizens who seek to reduce transportation costs by using public transportation.

Keyword: fuel consumption, transportation, geography, costs, costs

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Resumen

Los elementos del control interno aseguran la eficiencia y eficacia en las operaciones de intermediación financiera. La investigación se desarrolló en una cooperativa de ahorro y crédito de la ciudad de Ambato – Ecuador, controlada por la Superintendencia de Economía Popular y Solidaria SEPS. Vislumbrando algunos elementos del control interno - COSO I. Las cooperativas de ahorro y crédito mediante efectivo reciben depósitos, entregan créditos y emiten tarjetas de pago. El apalancamiento de progreso institucional, obliga a la multiplicidad de ofertas y productos financieros no financieros, lo cual operativamente ocasiona riesgos, ante esto, la gestión del control interno asegura el cumplimiento normativo y la razonabilidad en los informes de caja y bóveda. El objetivo del trabajo es diseñar un Manual de Control Interno para la efectividad de las operaciones de caja y bóveda. Los datos fueron recogidos mediante el empleo de métodos empíricos encontrándose riesgos en el manejo del efectivo. Se implementó un manual de control interno donde señala políticas y procedimientos destinados al manejo adecuado de caja y bóveda. También indica el perfil profesional; proceso de selección del talento humano; actividades operativas y contables del efectivo. Y la normativa para la custodia del dinero.

Palabras clave: Control interno, caja, bóveda, cooperativa de ahorro y crédito, efectivo.

Introduction

Excessive traffic and mobility needs have created social, infrastructure, time and coverage problems due to the value currently provided by the urban transportation system, which does not meet the expectations of users. Public transportation in Ecuadorian cities is essential for their development, since it facilitates the movement of people. Without passenger transportation, urban areas cannot be consolidated; this is the responsibility of municipal or public institutions. Thanks to bus transportation, the circulation of other vehicles on the road is positively affected, since a cab can transport up to five people on the road and occupy an average surface area of 13.5 square meters per person, while a public bus can transport up to 60 people and occupy a surface area equivalent to that of two vehicles.

The characteristics of transportation and the services they offer are a problem in modern cities and have a direct impact on the socioeconomic structure and quality of life of the inhabitants, with Ecuador being considered a dynamic country in rapid development, but its physical and demographic growth is uncontrolled, with the result that public transportation service is affected. (Badoe, 2020, pp. 107-116)..

In order to carry out the study on transportation in the DMQ different types of objectives were met, the general objective of this study is based on, "Analyze the geographical variable that influences the final cost of the ticket of the public transport system. As specific objectives "Define a value of average fuel consumption of transport units" as well as "Determine the percentage of existing gain / loss in each route made" For this

3 routes will be identified at Quito level (Travel to Ecuador, 2020), which are able to demonstrate whether or not this factor called slope will influence the final cost of the ticket.

In order to elaborate this research, a descriptive methodology was used, through data collection in the different study routes with their respective characteristics, without taking into account factors external to the study, with the purpose of analyzing the scope of the impact of public transportation services in the country.

According to Celi (2018)there is currently a huge shortage of professional drivers, with many people who have never driven a bus, even if they have a license, and many others who know how to drive a bus, but do not have a license. The municipality, through its agencies such as the Secretariat of Mobility, the AMT and the Mobility Management Center, is absolutely responsible for urban transport in Quito, controlling fares, routes and companies.

According to Higuera (2019) in the city of Ibarra it is identified that one of the transport units has a lower fuel consumption in relation to the other transport operators, where its consumption is 17,518 gallons per day; Determining a specific fuel consumption is one of the main reasons for study in some of the cities throughout the country, this being a reference item with respect to the average consumption, being used as an example of the analysis that will be applied in this research.

As a consequence, it has generated the need to investigate in addition to corroborate the transportation system, due to that different types of projects have been carried out that evidence it, such as the scientific article Geography of Transportation made by Florencia Serrano in the year. (2017), which details the progress of the transportation system over time, as a necessity of humanity. On the other hand, the research "Incidence on the mobility of the main factors of a changing metropolitan model that reflects the changes of mobility over time for the benefit of human beings. (EURE, 2018).

There are legal regulations that facilitate and provide security to the transportation system, such as the Organic Law of Land Transportation, Transit and Road Safety (Ley Orgánica de Transporte Terrestre, Tránsito Y Seguridad Vial), (2008) the objective of which is to organize, plan, regulate, modernize and control land transportation, transit and road safety, as well as to protect people and goods moving from one place to another on the road network.

Frequent starts, accelerations and stops in urban cycles lead to high fuel consumption; in these cases, inertia forces play the most important role. As a result, many studies have shown that a trailer consumes 50% more fuel in the urban cycle than in the outdoor cycle, where speeds are more constant. (Grijalva, 2019).

Table 1. *Driving on slopes*

Definition
The force of the slope is the main resistance to the vehicle's progress and requires a greater effort from the engine to overcome it. It is necessary to obtain a gearbox ratio that allows operation in the green zone and as close as possible to the maximum, which is the ratio that guarantees maximum traction. (Fabela, et al., 2019).
The weight of the vehicle causes an increase in its speed when driving downhill. During the descent, it is not important to work outside the green zone because the

accelerator is not used, i.e., no more fuel is injected into the engine than at idle. (Fabela, et al., 2019).

A body generates friction that retains or decreases its acceleration by rubbing against a particular surface, but, considered in the real world, in addition to this factor, the air resistance of a moving body is included. The acceleration of a moving body will be affected on various scales by the force of the air, by the slope and by the existing coefficient of friction. (Rex & Wolfson, 2011).

Note: Own elaboration 2022.

However, the study of driving on slopes in this study will be affected by the type of driving, the elevation grades at which the DMQ is located, the slopes being represented in percentages, being a way of expressing the relationship between the height we overcome when ascending the road and the distance we move horizontally. These operating costs are defined as all the money spent by an organization to convert stock into output. Included in them, direct labor and all operating and maintenance costs. (Alvarez & Calle, 2014). In order to determine the tariffs, it is necessary to take into account the real operating costs of the unit, its maintenance throughout its useful life, the number of kilometers traveled, the number of users, fuel consumption, etc., in order to offer a quality service, i.e. comfortable, safe, fast and fair tariffs for both operators and users, (Villamarín, Padilla, Guerrero, & Llamuca, 2019)..

Table 2. *Operating costs*

Type of operating cost	Cost
Service production	Mileage
	Days of work
	Operating vehicles
	Number of service passengers
	Number of passengers mobilized
Inputs used for service production	Labor
	Vehicle maintenance and repair
	Fuels and lubricants

Note: Own elaboration based on data from. (Álvarez & Calle, 2014)

However, according to the National Transit Agency of the Republic of Ecuador (Agencia Nacional de Tránsito de la República del Ecuador) (2021) indicates that, immediately in Ecuador, the factors that affect urban bus fares are fixed and various variable costs, defined as follows.

Variable costs are totally subject to the route where the vehicle travels. In this way, depending on the slopes and the range of the route, the amount of fuel that is spent in the transit of the route will be shown, and depending on the price at which the fuel is found, the total investment in fuel will be determined.

The tire wear due to the mileage driven and the driving situation (existing slopes) reflects how often a tire change should be performed.

Fixed costs are subject to the administrative processes by which the transportation operators determine their costs such as: labor, legalization, depreciation and

administrative expenses such as the use of infrastructure that the operators have and give daily use, which influence the determination of a rate for the use of transportation in the DMQ.

Table 3. *Definition of operating costs*

Type of cost	Cost	Item
Fixed	Labor	Driver's salary and legal benefits. Assistant's salary and legal benefits.
	Legalization	Vehicle registration. Operating and Enabling Permits. Vehicle Technical Inspection. Tax on filming. Public Service for the Payment of Traffic Accidents. Others determined by competent authority.
	Depreciation	Value of the annual depreciation of the vehicle, including the residual value.
	Administrative expenses	Costs related to the infrastructure to operate and control a route. Administrative costs with consortiums.
	Others	Other justified expenses that are determined or required by the bylaws of the cooperative or transportation company.
Variable	Fuel	Fuel prices.
	Tires	Change or replacement of tires.
	Preventive and corrective maintenance	Apply vehicle maintenance if necessary. Route (slope, fuel consumption, tire cost)

Note: Prepared by the authors based on data from (National Transit Agency, 2021).

Materials and methods

The research method is based on the collection and analysis of data that answer the research questions and support the hypothesis previously established. This article keeps a field and experimental design type, specifically quasi-experimental and quantitative. In this way, the technique to be used will be the practical collection of data necessary for the final analysis of the passage, it will be possible to expose the incidence that the geographical context factor has, especially the slope in the final value of the passage. The dependent and independent variables have been established as follows: the dependent variable is the driver of the means of transport, the vehicle driving, the vehicle load and the speed. While as independent variable the route is taken into consideration, as well as the driving cycle, the altitude and acceleration of the vehicle, without taking into account external factors such as the price of a barrel of oil, political factors such as presidential changes, national strikes, etc.

In order to carry out the present study, different materials were used, which were essential to obtain the correct data to be analyzed and finally to fulfill the research objectives. (Asaiain & Margall, 2000)..

According to INEN 1668 standards the vehicle used is a two-axle vehicle with a total length of 10,250 mm long and with a height of 3,800mm high to achieve compliance with national standards and enter into correct operation. (INEN, 2015).

Table 4. *Study vehicle*

Material	Description
Vehicle	Bus (HINO AK8JRSA) Capacity (60 PASSENGERS) Horsepower (7684 CC) Power: 247 HP @2500RPM Tank capacity (300L)

Note: Own elaboration based on data from: (Mavesa, 2022)

The DMQ mobility secretariat specifies that the routes are managed by different operators, taking into account two different operators for the study to be carried out: Lujo express águila dorada, which has two lines for the study (Roldós/jardín, Velasco/ejido), and the second operator, alborada compañía de transportes S.A., with the terminal Ofelia/seminario mayor route. (Mobility, 2021). The routes used for the study have different routes through the city, in such a way that it is possible to differentiate the geography present in the DMQ. These routes clearly define the geographic differences of the DMQ, being specific with the Ofelia/Marín route that has a semi-linear route, capable of complying with an ideal driving and establishing consumption values in order to make a comparison of the condado/congreso and jardín/Roldós routes that have a higher elevation, as well as a greater amount of positive and negative slopes.

Table 5. *Study routes*

Description	Specific description
Route	COUNTY - CONGRESS JARÍIN - ROLDOS OFELIA - MARIN

Note: Own elaboration 2022

Public transportation in the DMQ is in constant use, however this means of transportation is not the only one in the city, the traffic in the city is one of the factors

that determine the schedule to be used in this research, the schedule to be used for the practical part of the research is in the early hours of the morning, from 1AM to 2AM. This time range is the correct one to determine an ideal driving cycle that allows to perform the analysis according to the research.

Under the Ecuadorian Technical Standard NTE INEN 2 205:2010 (2010) and Art. 191 of the Regulation to the Law of Land Transportation, Transit and Road Safety (2016) which establish speed limits adapted to the vehicle and place of circulation, respectively. Making use of these regulations because it is attached to the use of urban buses in Ecuador, and thus govern the work to the rules within the territory where the research is applied.

It consists of two driving cycles, the first one considered constant, which will be 50 km/h (driving cycle for public and commercial passenger transport vehicles in urban areas) and the second one will be between 50 km/h and 90 km/h (driving cycle for public and commercial passenger transport vehicles in straight areas). While the technical standard DIN 70030, is a standard that focuses on the vehicle load, the test route, weather conditions and the test speed being used to determine the fuel consumption in a complete route, providing information to make a relationship with respect to consumption and tank volume, entering into comparison of different routes that have different variables that affect the type of driving and consumption.

The fuel used by the transport to travel each route is Diesel, which is currently priced at $1.75 per gallon. (Torres, 2022). This type of fuel is used because most of the urban buses in Ecuador currently use this type of fuel, and it is also the most economical for the project. Currently, 26,251 buses circulating in the country run on diesel or gasoline. Of these, 20,444 are 15 years old or less. That is, they are within 20 years of their useful life. (COMERCIO, 2019).

Table 6. *Studio equipment*

Measuring equipment	Specific equipment
Altimeter	Altimeter Offline
Variable	Fuel prices
GPS	Google Maps
Scanner	G-SCAN 2
Speedometer	HINO vehicle

Note: Own elaboration 2022

Results

The following table represents the variables that were taken into account for the study to be carried out, the temperature taken into account at the moment of starting the test, the length that represents the complete route of the transport route; the time in which the route was carried out, as well as the density of the fuel (Diesel), in order to know the fuel consumption in each route.

Table 7. *Route characteristics*

Variable	Route #1	Route #2	Route #3
Temperature	9	10	15
Earrings	6	7	3
Length	37 km	28 km	34Km
Weather	5760s	6000s	5160s
Diesel Density	0.832 kg/cm^3	0.832 kg/cm^3	0.832 kg/cm^3

Note: Own elaboration 2022

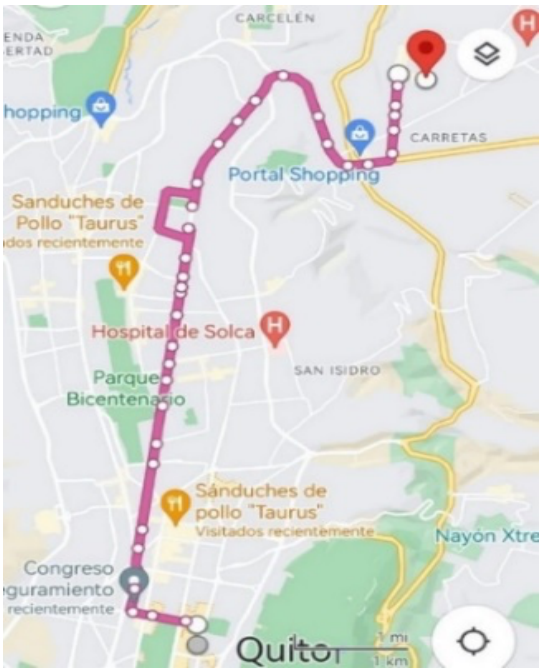
In the present research will be analyzed based on a qualitative mathematical model, being described in terms of variables, as initial data is considered the fuel consumption per hour [g/h], depending on the fuel density [g / h], once obtained the initial data is important to know that the specific consumption [g / kWh] taken into account as an important factor to finally determine the actual consumption in liters per hour [l / h].$\boldsymbol{cm^3}$Once the initial data is obtained, it is important to know that the specific consumption [g/kWh] will be considered as an important factor to finally determine the real consumption in liters per hour [l/h]. In order to determine the consumption per hour, the relationship between the fuel consumed by the density of the fuel used for the test is used, being directly proportional to the duration of the test. While the specific consumption will be reflected in the fuel consumption which is directly proportional to the engine power.

In order to determine the specific consumption values for each route of the study, the total distance, number of slopes, time of duration of the test and the density of the fuel in the DMQ (Diesel) are analyzed. With this, the following results will be obtained and we will proceed with the discussion of each of these values to reach the conclusions of this study.

Distance and critical points County-Congress

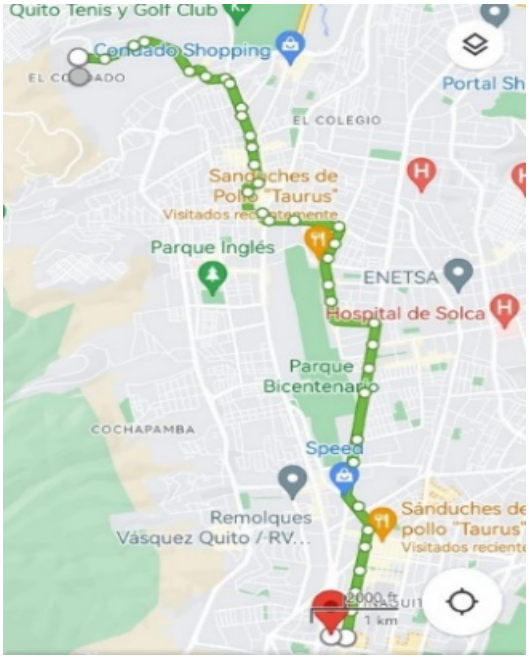
It shows the route that was established to perform the test; that is to say, this image shows the distance (37km), the critical points traveled when performing the movement and the number of slopes (6) with an approximate inclination of 35°, where the fuel consumption of public transport is analyzed according to the ideal driving cycle.

Figure 1. Distance and critical points Garden-Roldos



It shows the route that was established to perform the test; that is to say, this image shows the distance (km), the critical points traveled when performing the movement and the number of slopes (7) with an approximate inclination of 40°, where the fuel consumption of public transport is analyzed as a function of the ideal driving cycle.

Figure 2. Distance and critical points Ofelia-Marín



It shows the route that was established to perform the test; that is to say, this image shows the distance (km), the critical points traveled when performing the movement and the number of slopes (3) with an approximate inclination of 20°, where the fuel consumption of public transport is analyzed in terms of the ideal driving cycle.

Fuel consumption is directly proportional to the flow of traffic present at the time of travel. All the movements and fuel consumption tests are in function of the TPS, it can be seen in the figures that in most of the movements the fuel consumption is directly proportional to the TPS, independent of the results, performing a single test does not indicate a conclusive value.

The injection systems aim to achieve a fuel dosage as adjusted as possible to the driving conditions and engine condition, this test was developed with the intention of obtaining mass flow data that depends on the speed of the run, the information obtained remains constant between 519 - 779 [mg/stroke] in an almost linear way during the tests performed, the engine performance and pollutant emissions depend basically on the composition of the stoichiometric mixture.

The routes used in each test, as well as the load used reflect a real operation, allow to determine the analysis of fuel consumption data, since it allowed to observe the behavior of the vehicle circulating through each movement, the variation between the different routes is due to the type of driving that occurs in the city, where the circulation is affected by braking and sudden accelerations, producing a higher fuel consumption regardless of the distance traveled.

Once the fuel consumption values were obtained from the different tests, an average consumption was established for each route, determining the amount of fuel required to complete each of the routes. Fuel consumption varies according to the type of driving, geographic conditions, since each of these differs in fuel consumption.

It shows the fuel consumption values obtained during the different routes; an average consumption was established to determine the amount of fuel required to complete each of the routes, in liters per hour, based on the mathematical model applied throughout the research.

Once the fuel consumption of the routes within the DMQ has been obtained and knowing that the current value of diesel in Ecuador is $1.75, the cost of traveling on the different routes can be established according to the vehicle used in the study.

As a result of this investigation, it can be determined that route #3, despite having a total distance of 34 km, has a lower consumption than average, since fuel consumption varies according to geographic conditions and type of driving, obtaining a value of 0.332 L/H, comparing this data with route 1 with a value of 0.398 L/H, far from the average value, as well as route 2 with a value of 0.445 L/H.

Conclusions

With the collection and analysis of data obtained at the time of each driving cycle, the operation of two specific sensors (MAF-TPS) was analyzed, which, working together, made it possible to analyze the intake air control, keeping it between 519-779 mg/stroke in most of the tests carried out throughout the research, thus determining the exact amount of fuel required to perform each of the runs, based on an adequate air-fuel mixture.

Fuel consumption varies according to the route and the way the driver drives, since each of these differs in its different geographical conditions, duration of the route and load with which the vehicle travels, being route 3 (Ofelia-Marín) the one that maintains a lower fuel consumption, with a value of 0.332 L/, being this the route that maintains a total distance greater than the other routes (34km). Determining that in this route the ability to maintain more constant speeds and the fact of being the most linear route compared to the three routes studied, the values obtained in an ideal cycle performed in the tests of this route place it as the most appropriate route when moving through the DMQ, However, the percentage of profit that represents the value of the passage for each transport operator is high, due to the fact that the transport units do not take into account the load with which the means of transport should circulate; This results in an agglomeration of people in each unit, which positively affects the profits of each operator but compromises fuel consumption as well as customer service and in the future affects the useful life of the vehicles.

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