Faculty of Operation and Economics of Transport and Communications
University of Žilina
Žilina, Slovakia

TRANSPORT AND COMMUNICATIONS

Scientific journal

tac.uniza.sk

I/2020 Volume VIII ISSN 1339-5130

TRANSPORT AND COMMUNICATIONS

Scientific journal intended to combine theory and practice in the field transport and communications and thus advancement of transport and communications sciences

DOI: 10.26552/tac.J.2020.1
ISSN 1339-5130

Table of contents

Transport and Communications, 2020; Vol. I.
ISSN: 1339-5130

DOI: 10.26552/tac.C.2020.1.1

Identification of Refund of Excise Duty on Motor Oils in International Road Freight Transport

Juraj Hammer[1], Miloš Poliak[1], Marek Jaskiewicz[2]

[1]University Of Zilina, Univerzitná 1, 010 26, Žilina, Slovakia
[2]Kielce University of Technology, Al. Tysiaclecia Panstwa Polskiego7, 25-314 Kielce, Poland

Abstract In this article, the authors focus on the issue in the field of refund of excise duty on motor oils within Europe. Some states have a refund in their legislation, most European countries do not, and this creates pressure from carriers to make decisions, where and how much it pays to refuel with their vehicles in international transport. Survey research has been created for this article, analyzing and comparing the conditions for creating a competitive environment across Europe. The artikle also wants to point out that reimbursement is not subject to national transport, respectively international transport and drawing by foreign carriers in countries is supported, where a refund is made.

Keywords road freight transport, duty on motor oils, refund on excise duty, international transport

JEL R49, L91

1. Introduction

The tax revenue from the excise duty on mineral oils can be classified as one of the highest, which are credited to the state budget of the country. As the degree of automation increases every year, it is assumed that income to the state budget should also increase. However, fuel costs also have a big impact on income. In the case of road freight transport, if the carriers perform the international carriage of persons or goods, it is more convenient for them to refuel there, where they are the cheapest, or where there is a possibility to use the excise duty refund on mineral oils. The main reason why carriers make this decision is that fuel costs are the largest cost item. These costs represent approximately 30% of the costs. Currently, it is possible to use the option of refunding excise duty on mineral oils for given vehicle types in 6 EU member states. These countries are more competitive than others. This also increases the income to the state budget of these countries. If other countries also want to be competitive, two options can be used. The first option is to set a minimum level of taxation. However, this determination would be for all vehicles and therefore the situation could be that the revenue to the state budget rather decreased. The second option is precisely to determine the refund of excise duty on diesel fuel and based on conditions that are already in place in those states.

2. Comparison of conditions in Slovakia and abroad

Since 2010, the EU Member States have been obliged to comply with the minimum level of taxation of excise duties on mineral oils according to two legal standards. The first is Council Directive 20023/96 / EC of 27 October on the restructuring of the Community legal framework for the taxation of energy products and electricity The second piece of legislation is Council Directive 2004/74 / EC of 29 April 2004, amending Directive 2003/96 / EC as regards the possibility for certain member states apply temporary exemption in respect of energy products and electricity or lowering the tax rate. The standard was adopted because of the transition period, where countries did not have to immediately apply a minimum level of taxation. This was intended for countries where the minimum rates laid down in Directive 2003/96 / EC would create serious economic and social difficulties and could have an adverse effect on nationals and national economies. Member States such as Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia and the Slovak Republic could apply the transitional period. At present, member state cannot apply this transitional period and must comply with a minimum level of taxation for excise duty on diesel of € 330/1000 litres.

2.1. Excise duty on mineral oils in Slovakia

Excise duty is an indirect tax of a selective nature, which applies only to the selected goods. These are:

- alcoholic beverages (alcohol, beer, wine, intermediate)
- tobacco and raw tobacco,
- electricity, coal, natural gas,
- mineral oil (eg diesel, petrol, LPG) [1].

Excise duties are indirect due to the fact that they are not paid by the LP (legal person) and IP (individual person) directly, but on the purchase of the above goods and the excise duty is introduced in the selling price. This article

analyses the excise duty on mineral oils. Mineral oils are taxed by two indirect taxes, namely VAT and excise duty on mineral oils. Indirect taxes are a significant revenue for the state budget [2]. The table (Table 1) shows the selected revenues of the state budget for the monitored periods. Revenue is of a growing nature and is expressed in bill euros.

Table 1. Selected state budget revenues for the period under review in bill.€

Period / Income	2017	2018	Estimate 2019
Tax revenue	11.141	11.968	12.46
VAT	5.922	6.420	6.63
Excise taxes	2.253	2.324	2.42
Mineral oils	1.232	1.267	1.33

Source: authors

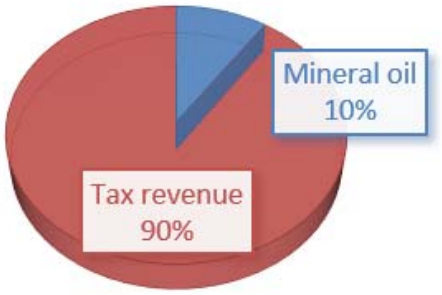

Figure.1. The share of excise duty on mineral oil in total tax revenues for 2018 Source: authors

From the picture (Fig. 1) we find out that the component of excise tax on mineral oils contributes to the total tax in SR as of 31.12.2018 approximately 10%.

3. Excise duty on mineral oils abroad, where a refund is applied

Part of this article is dedicated to individual states that are legally allowed to refund part of the excise duty on mineral oils. Refunds apply to those carriers who have pumped diesel with vehicles over 7.5 tons or M2 and M3 vehicles, or buses. These vehicles are due to the minimum fuel requirement, so that a refund is recognized. In France, Slovenia and Italy, it is possible to send documents on CD-ROM.

Belgium

In Belgium, part of the excise duty will be reimbursed in the case of refueling with vehicles with a payload of over 7.5 tones. Refunds are available up to 3 years after the withdrawal date, but only if the client has a valid license. A copy of the RITA (TRP / VIT internal program) license must also be provided, because the card number is needed. The minimum annual refundable amount of TRP / VIT is 260 €, quarterly € 1.000. Treasury documents are not acceptable [3-5].

France

Refunds apply to vehicles with a payload of over 7.5 tons and for buses. The condition of TRP / VIT is that the carrier has to refill at least 5 600 liters every six months. Treasury documents are not acceptable [3-5].

Italy

Part of the excise tax can be refunded when refueling diesel vehicles with a payload of over 7.5 t and buses. It is necessary to apply every two years after the period. In 2016, a TRP / VIT minimum rate of € 214.18609 / 1000 liters was provided. Treasury documents are not acceptable [3-5].

Slovenia

The refund of part of the excise duty concerns the refueling of vehicles with a payload of over 7.5 tons and for buses. At least 6,500 liters per year are required. Cash receipts are only allowed if all details are given and paid by card [1-3].

Spain

In Spain, refunds are granted for vehicles over 7.5 t and buses. The request cannot be retroactively. It starts from the date when the new Gasóleo Profesional refueling card began to be used. TRP / VIT makes a refund only if the client draws max. 50 000 liters, for the second year at least 25 000 litres. The basic condition is that foreign transport companies must have a NIF number if it is a. r. o./a. s., or NO number for sole traders in Spain. This is a tax identification number for foreigners. All documents must be sent to Murcia to receive the NIF number. [3-5] TRP / VIT registers a client in Spain if he sends a NO number to Murcia with an extract from the AB translated into Spanish and Apostille, with a copy of his passport or director's identity card (person signing the documents) and with two attached permits. [35] It is very important for all authorities to know that if a TRP / VIT company registers a company on its behalf it must be clear whether this is a new registration or just a change of representative. The form must be completed in any case. This means that the client needs to know if he is registered in Spain and if so, the NIF number and name, address and NIF of the agent (at least the name) [3-5].

Hungary

It is possible to refund the excise duty on mineral oils if it pays diesel fuel with vehicles with a payload of over 7.5 t and buses. The application to the tax office is required by 31.01.2017 for the period 01-12 / 2016. Refundable amount from 01.01.2016 is 7.00 HUF / liter. Treasury documents are not acceptable. [3-5]

Summary

The table (Table 2) shows the current rates of excise duty for countries where refunds are possible. By comparison, we find that Belgium has the highest return chance. One of the reasons may be the increase in the mandatory tax rate from January 2018. Hungary has the lowest refund amount. All rates are set by the customs offices in the countries concerned and by the competent European authorities. [] Excise duty refunds may be up to 24 eurocent per liter, however, carriers must reckon that excise duty refunds will only be made under certain conditions, e.g. registration in that country for the purpose of refunding excise duty, using fuel

DOI: 10.26552/tac.C.2020.1.1

cards for a specific vehicle registration number or the amount of liters consumed for a particular period. [4]

Table 2. Country excise rates applicable to international transport companies Source: authors

Country		*Rate € / liter*
Belgium		0.2476158
France	**Trucks**	0.1775
	Buses	0.2175
Italy		0.21418000
Slovenia		0.06272
Spain		0.048
Hungary		7 HUF/l – 0.2*

* exchange rate 04.03.2019

In the following part of the article we will also look at other states within the EU group. The table (Table 3) shows the excise duty on gas oil in the EU member states.

Table 3. The amount of excise duty on gas oil in the EU member states from 1.1. 2018

Country		*Excise duty rate*		
		National currency		
Belgium	**> 10 mg/kg**	EUR	554.1618	-
	≤ 10 mg/kg		538.4522	-
Bulgaria		BGN	646	330.29
Czech Republic		CZK	10 950	421.2349
Denmark		DKK	3 139	421.8066
Germany	**> 10 mg/kg**	EUR	485.70	-
	≤ 10 mg/kg		470.40	-
Estonia		EUR	493	-
Greece		EUR	410	-
Spain		EUR	331	-
France		EUR	594	-
Croatia		HRK	3 060	408.1633
Ireland		EUR	479.02	-
Italy		EUR	617.40	-
Cypress		EUR	450	-
Lithuania		EUR	347	-
Latvia		EUR	372	-
Luxem-burg	**> 10 mg/kg**	EUR	338.3548	-
	≤ 10 mg/kg	EUR	335	-
Hungary	**Crude oil > 50 USD/barell**	HUF	111.966	359.5107
	Crude oil ≤ 50 USD/barell	HUF	121.966	391.6196

The figure (Fig. 2) shows a comparison of changes in excise duty rates. From 01.01. In 2018, thirteen member states increased the amount of excise duty. Romania was the only one to reduce excise duty. Although Poland has raised the rate in national currency, it represents a lower rate in euros than the previous one. In Bulgaria, the Czech Republic, Germany, Spain, Croatia, Ireland, Italy, Cyprus, Luxembourg, Malta, Austria, Slovenia and the United Kingdom, the amount of excise duty has remained unchanged since 1 July 2016. The Slovak Republic changed the rate, but for the second type, where gas oil is biodiesel free. Hungary has regulated tax collection in two ways. A lower tax is when the price for crude oil is higher than $ 50 / barell. A higher tax is levied if the crude oil price is equal to or greater than $ 50 / barell [5].

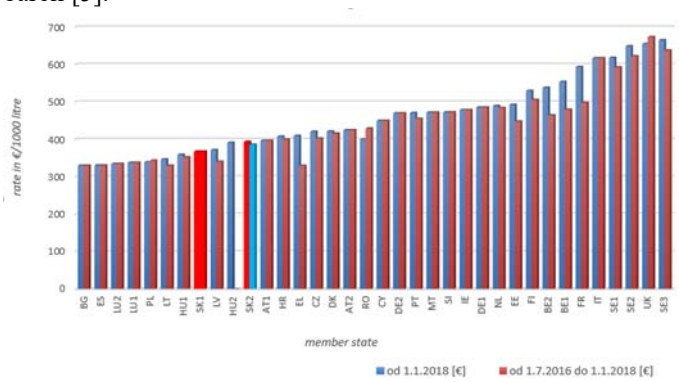

Figure. 2. Change in excise duty rates on mineral oils in EU member states Source: authors

Diesel prices are affected not only by the excise duty on mineral oil, but also by the value added tax. The table (Table 4) shows the VAT for each EU Member State expressed in %, ranked from lowest to highest. Luxembourg has the lowest VAT and Hungary has the highest VAT. The Slovak Republic has the 10th lowest VAT and at the same time, 6 EU countries also have 20% VAT as Slovakia [6-8].

Table 4. Value added tax in EU member states Source: authors

Country	VAT[%]	Country	VAT[%]
Luxemburg	17	**Lithuania**	21
Malta	18	**Latvia**	21
Germany	19	**Netherland**	21
Cypress	19	**Italy**	22
Romania	19	**Slovenia**	22
Bulgaria	20	**Greece**	23
Estonia	20	**Ireland**	23
France	20	**Poland**	23
Austria	20	**Portugal**	23
Slovakia	20	**Finland**	24
Great Britain	20	**Denmark**	25
Belgium	21	**Croatia**	25
Czech Republic	21	**Sweden**	25
Spain	21	**Hungary**	27

The price of diesel fuel in € / liter with VAT and excise tax is shown in the figure (Fig. 3). As we can see, the average price of diesel in the EU was € 1,346. The Slovak Republic drew the 13th cheapest diesel of € 1.251 / liter, so we have a lower price than the EU average. Neighboring countries of the Slovak Republic have a lower price, only Hungary is on the same level, so only one cent is higher. Luxembourg also had the cheapest diesel in 2017 but also in 2019, where in 2019 it is € 1,101 / liter. Great Britain pumped the most expensive diesel at € 1,518 / liter.

4. Research in the field of reimbursement of excise duties on motor oils carried out on a sample of inquiries from transport companies

The authors of the article conducted a research focused on Slovak carriers operating international road transport. Fuel costs can be classified as the highest variable cost items in road transport. Depending on the classification of transports, in particular as regards long-distance or short-distance transport, they may account for up to 40% of the total annual cost. These costs may be affected by the carrier in several ways, eg:

- selecting fuel suppliers;
- optimization of fuel consumption due to different fuel prices abroad;
- the possibility of refunding excise duty on diesel in selected countries [9].

In the latter case, the possibility of reimbursement of part of the excise duty paid on diesel fuel would be able to reduce fuel costs. This subchapter evaluates the obtained data whether the possibility of cost reduction is also used by carriers in the Slovak Republic.

In order to find out the situation in the Slovak Republic among carriers carrying goods or passengers within the EU on the topic of refunding excise duty on diesel fuel, the authors conducted a survey. The carrier's e-mail addresses have been obtained through the carrier's register on the website of the single road transport information system. Not all carriers provide a contact email in the carrier register, or the email address was invalid or the addresses did not receive mail. Based on this, 300 emails were sent to carriers established in the Slovak Republic. Some have also taken into account the number of vehicles where the authors have focused on those who have indicated that they have licenses for more than 10 vehicles. The questionnaire consisted of five simple questions and that:

1. Do you use the possibility of refunding excise duty on mineral oils abroad?
2. If you answered yes, please select from which country (s).
3. Please indicate the amount (€ / year).
4. If you introduce a refund of excise duty on mineral oils in Slovakia, what are your recommendations?
5. What is your experience with the refund of excise duty on mineral oils?

Figure. 3. The answer to the question of using excise duty refund Source: authors

The figure 4 shows the answers to the second question. They had the opportunity to mark multiple answers on this question. Most refunds will be made from Belgium. This may be due to the highest refund of excise duty or to multiple shipments to this country. Least refunds will be made from Spain.

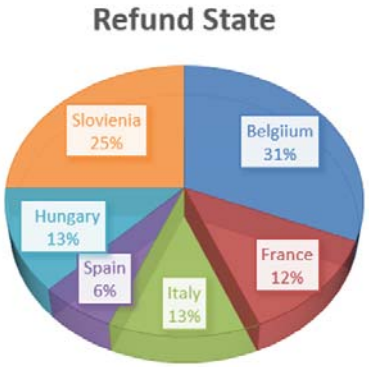

Figure 4. Answer the question about the place of refund Source: authors

The answers to the third question concerning the amount to be paid in respect of the refund of the excise duty on diesel for the year expressed in euro are given in the figure (Fig. 10). How can we assess the amounts are diverse, starting with the lowest of € 1,200 / year up to the highest of 75 000 € / year. As stated in the previous question, the reasons may be different.

DOI: 10.26552/tac.C.2020.1.1

Figure 5. The answers of the value of refund price in €/year Source: authors

The fourth question was focused on recommendations of the way of refund, in case of introduction of refund of excise tax on mineral oils in Slovakia. The answers were different from carriers, for example, it is recommended to introduce:

- Fast processing, quick refund, online submission
- for Slovak carriers not to impose a limit of liters from which tax will be refunded,
- emphasize that the entire refund process is not unnecessarily complex (overly bureaucratic);
- reduce application processing time;
- fast payback, online submission.

The responses point out that if the excise duty on mineral oils is introduced in our country, the focus is mainly on the correct setting of the processing time for applications. As one of the carriers said, there is no need to think about the new conditions, but it is necessary to compare the countries that already have an excise refund procedure in place and to conclude the most appropriate system to which international road hauliers would agree. The experience of carriers is diverse. The problem is mainly the process of tax refund of diesel fuel in Belgium, where the country has set a longer time period for tax refund compared to eg. Spain. However, this problem cannot be influenced.

The responses also mention external specialized companies that are involved in this service. One carrier has good experience and the other does not. It depends on each carrier the company chooses. In the Slovak Republic, we can find that there are several such companies. When choosing a company in such a case, one can focus on the amount of commission for the company it requires in the event of handling a refund for the carrier in the desired country. This commission may vary from country to country, as the refund process may be more difficult in a country. As the documents required for the recovery of the diesel tax and the rates are set by the competent authorities in the countries, this would not have to play a role in the selection of an external company that carries out the excise duty refund service.

5. Conclusion

This article focuses the issue of excise duties on mineral oils for road freight transport. Carriers, when they want to reduce their cost items, are looking for solutions to how to do it. Mineral oil excise tax refunds are one of the options where fuel can be saved abroad for the international transport of goods. The article and its research showed different taxation in EU countries where one member state is more competitive than the other. EU legislation allows you to adjust the amount of this tax at will, however, at a minimum set limit of 330 € / liter. Only in 6 EU member states is the excise duty refund on mineral oils applied. The research carried out in this article also points to the external costs of excise duty and also to the correction taxes for diesel. Research has also been carried out in the field of excise duty refunds on a sample of inquiries from transport companies involved in this issue. Carriers still make the most use of a refund in Belgium, where the largest amount of refund is € 0.24 / litre.

ACKNOWLEDGEMENT

This paper has been developed under support of project: MŠVVŠ SR VEGA No. 1/0566/18: Research on the impact of supply and quality of transport services on the competitiveness and sustainability of demand for public transport

REFERENCES

[1] Holguín-Veras J, Zorrilla JC, Thorson E (2005b) Modeling commercial vehicle empty trips: theory and application. XVI International Symposium of Traffic and Transportation Theory (ISTTT), pp. 585–608, H. Mahmassani (Editor), Elsevier

[2] Hautzinger H (1984) The prediction of interregional goods vehicle flows: some new modeling concepts, ninth international symposium on transportation and traffic theory, VNU Science Press, pp 375–396.

[3] Hong-wei Z, Wen-long W (2004) Safety analysis of over-size and over-load in road transport. J Highw Transp Res Dev 21(3):132

[4] Debski, H., Koszalka, G., Ferdynus, M.: Application of FEM in the analysis of the structure of a trailer supporting frame with variable operation parameters. Eksploatacja i Niezawodnosc—Maintenance and Reliability. **14**, 107–114 (2012)

[5] Braghin, F., Cheli, F., Melzi, S., Resta, F.: Tyre wear model: validation and sensitivity analysis. Meccanica **41**, 143–156 (2006)

[6] Borowiec, M., Rysak, A., Betts, D.H., Bowen, C.R., Kim, H.A., Litak, G.: Complex response of the bistable laminated plate: multiscale entropy analysis. Eur. Phys. J. Plus **129**, 211 (2014)

[7] Bowersox, D.J., Closs D.J., Cooper M.B.: Supply Chain Logistics Management, McGraw-Hill/Irwin, New York, (2002)

[8] Vargo, S. L., Lusch, R. F.: Evolving to a new dominant logic for marketing. Journal of Marketing, no. 68, January, 1–17 (2004)

Framework for Electromobility in the Slovak Republic and Its Application at the Local Level

Karol Hrudkay[1], Jaroslav Jaroš[2]

[1] University of Žilina, University Science Park, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic
[2] University of Žilina, University Science Park, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic

Abstract The article deals with conditions for the development of electromobility in the Slovak Republic at the national level and at the level of municipalities. The framework at the national level is analysed, consisting of a set of strategic documents adopted at the level of government resolutions, some of which are devoted more generally to alternative fuels. The strength of the documents varies, from the material referred as a recommended one, through the material required by the European Commission to an action plan with defined measures. The second part outlines a possible approach of a municipality to a changing framework at the national level. Experiences are presented as municipalities have grasped the issue of electromobility in their documents and an example of good practice where the whole national framework was taken into account comprehensively. Possibilities to improve the readiness of municipalities for challenges related to the conceptual solution of electromobility at the level of municipalities were identified.

Keywords Electric vehicles, Charging infrastructure, National framework, Incentives, Municipalities

JEL H23, L98, H54, R58, O18

1. Introduction

In compliance with sustainable transport trends, alternative fuels have been increasingly preferred, with electricity probably playing a major role in the future. In the case of the deployment of battery electric vehicles (BEVs), a significant reduction in local emissions is achieved, which is very important in the case of settlements or agglomerations that are found in poorly ventilated basins and valleys.

In the previous period, the issue of starting a more massive extension of electromobility has been discussed in the professional circles, especially the relationship between insufficient charging infrastructure and a commercially insignificant number of electric vehicles (EVs). However, there are more obstacles to the user, the principal barriers being: cost of purchasing an electric vehicle, insufficient charging infrastructure, the lifetime of the electric energy storage device, range of an EV per single charge and charging time, unresolved interoperability, and safety of energy storage [11]. A significant shift has been recorded in all these aspects, but some of them can also be affected by policy at the national level.

2. International context

2.1. Framework of European legislation

Based on an analysis of European legislation on electromobility and related aspects, the following legislative framework has been identified:

- Directive 2014/94/EU of the European Parliament and of the Council on the deployment of alternative fuels infrastructure
- Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources
- Directive 2009/29/EC of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community,
- Directive 2009/30/EC of the European Parliament and of the Council amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions,
- Directive 2009/31/EC of the European Parliament and of the Council on the geological storage of carbon dioxide,
- Decision No 406/2009/EC of the European Parliament and of the Council on the effort of Member States to

DOI: 10.26552/tac.C.2020.1.2

reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020,
- Directive (EU) 2018/844 of the European Parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency.

2.1. International technical standards

Progress in the area of international standardisation in terms of increasing the interoperability of individual components of the charging infrastructure and its security significantly affects the perceived level of attractiveness of electromobility from a user's perspective.

In this context, IEC 62196 (defines connector types) and IEC 61851 (defines charging modes) are considered to be the basic international standards, while the basic standard to ensure consistent communication between the charging infrastructure and the vehicle is ISO 15118 (defines communication interface between vehicle and grid).

All standards for electromobility constitute a very large set (its analysis is not the aim of this text). It is also important that at EU level the CEN, CENELEC and ETSI standardization authorities have been authorized since 2010 under mandate M/468 [3] to converge standards for charging electric vehicles. Furthermore, the issue of interoperability of collaborating systems in intelligent transport systems (M/453) [4] and the development of smart grid (M/490) [5] are subject to harmonisation efforts at a given level.

3. Political framework and strategic documents of the Slovak Republic for electromobility

3.1. Legislative framework

Considering the broad scope and interdisciplinarity of electromobility, the corresponding extent of related legislation is also extensive [9, 17, 24], inter alia it includes these laws and regulations (as amended):
- Act No. 71/2013 Coll. on the provision of subsidies within the competence of the Ministry of Economy of the Slovak Republic,
- Regulation No. 358/2013 Coll. laying down the procedure and conditions for the implementation and operation of intelligent metering systems in the electro energy sector
- Act No. 135/1961 Coll. on land communications (Road Act),
- Act No. 8/2009 Coll. on road traffic,
- Act No. 582/2004 Coll. on local taxes and fees for municipal waste and minor construction waste,
- Act No. 563/2009 Coll. on tax administration (tax code),
- Act No. 137/2010 Coll. on air,
- Act No. 372/1990 Coll. on offences,
- Act No. 106/2018 Coll. on the operation of vehicles in road traffic,
- Act No. 251/2012 Coll. on energy,
- Act No. 555/2005 Coll. on energy efficiency of the buildings,
- Act No. 595/2003 Coll. on income tax,
- Act No. 158/2011 Coll. on the promotion of energy-saving and environmentally-friendly motor vehicles
- Regulation No. 9/2009 Coll. on implementing of the Act on road traffic,
- Act No. 50/1976 Coll. on the spatial plan and building code (building act).

It should be also noted that this framework is subject to frequent changes, which also result from the implementation of the following strategic documents into practice.

3.2. Strategic documents

Even under the influence of external influences (the need for cross-border cooperation) and EU influence (transposition of the Directive [1]), since 2012 a set of conceptual and strategic materials for electromobility has been elaborated in the SR in charge of the Ministry of Economy. The process was long and complicated, but particular steps are now being taken to promote electromobility at the national level.

Below a brief analysis of these documents is mentioned with an emphasis on the electromobility measures stated.

3.2.1. Strategy of electromobility development and its effect on Slovak economy [6]

The strategy aims to exploit the potential of electromobility. This is conditioned by defining the preconditions for its development in order to initiate the systematic support and development of electromobility as a promising automotive industry. It formulates several possible objectives for the development of electromobility in the areas of economy, ecology and science and research. It proposes 16 system measures to support the development of electromobility, namely:
- including the electromobility issues in all relevant state strategies and policies,
- stimulation of growth of sales of electric vehicles and plug-in hybrids (PHEV) in Slovakia,
- support of science, research, development and innovation,
- information campaign,
- education in schools; teaching of new skills and knowledge in the education system,
- low-emission urban zones,
- consistent application of the principles of green public procurement when purchasing motor vehicles,
- simplifying of the administrative process for the construction of charging infrastructure,
- reservation of a public parking place for the owner of the charging infrastructure in the place of residence,
- reservation of public parking space for the owner of a publicly available charging station,
- introduction of legislative conditions for the mandatory deployment of charging infrastructures during the construction of parking spaces,
- deployment of a national network of charging centres,

- reservation of a parking place in the government´s car parks and subsequently build public charging infrastructure,
- provision of a contribution to the municipality for the construction of publicly available charging infrastructure,
- favouring of parking and entrance to urban centres and pedestrian zones for electric vehicles,
- conversion of conventional vehicles to electric vehicles.

The partial objectives of the strategy, as well as the set of system tools for the promotion and development of electromobility, are only recommendations.

3.2.2 National political framework for the development of alternative fuels market [7]

From the point of view of electromobility (the fuel is electricity), the document aims to support the development of the alternative fuels market in the transport sector and the development of the relevant infrastructure through the measures set out, focusing on:

- an assessment of the current state and future development of the market for alternative fuels in the transport sector,
- national targets and targets for biofuels, electricity supply for transport, natural gas supply for transport and, where appropriate, hydrogen supply for road transport, including the deployment of alternative fuel infrastructure,
- measures needed to ensure that national targets and objectives are met and measures that may support the deployment of alternative fuels infrastructure in public transport services,
- identification of urban/suburban agglomerations, other densely populated areas and networks, where, depending on market needs, publicly accessible charging stations shall be installed in accordance with the electricity supply requirements for transport.

The document also defines a set of measures that are relevant for electromobility:

- stimulating the promotion of low-emission vehicles for all types of use (private sector, municipal fleets operating municipal waste distribution vehicles, postal operators and fleets of urban public transport and public passenger transport services),
- support of alternative fuel infrastructure,
- a 50% reduction of the registration fee for motor vehicles using alternative fuels,
- introduction of low-emission zones,
- ensuring that road users are informed about the location, type and facilities of charging and filling stations through intelligent transport systems,
- education in schools; awareness of new skills and knowledge in the education system.

3.2.3 National policy of deployment of infrastructure for alternative fuels in conditions of the Slovak Republic [8]

As the main alternative fuels with long-term oil substitute potential are defined: electricity, hydrogen, biofuels, synthetic and paraffin fuels, natural gas and liquefied petroleum gas (LPG) namely because of their possible concurrent and combined use by e.g. systems of dual-fuel technologies.

In terms of electromobility, it determines the technical specifications for charging stations as follows.

Charging stations for conventional alternating current (AC) charging for electric vehicles shall, for interoperability purposes, be equipped with at least socket-outlets or vehicles connectors of type 2 according to EN 62196-2. Charging stations for high-power AC charging for electric vehicles shall be equipped with at least type 2 connectors according to EN 62196-2 for interoperability purposes. High-voltage direct current (DC) charging stations for electric vehicles shall, for interoperability purposes, be equipped with at least the 'Combo 2' charging system connectors according to EN 62196-3.

3.2.4 Action plan of electromobility development in the Slovak Republic [9]

The Action plan of electromobility development in the Slovak republic is linked to the abovementioned strategies and transposition documents approved by the Government.

The Action plan is a follow-up to the 3 adopted clean mobility packages. The Action plan proposes measures to ensure that users will perceive low-emission mobility as a problem-free, even with the aspect of speeding up the roll-out of the infrastructure. The measures reflect the objectives following from the aforementioned strategic documents, which are commitments of the Slovak Republic [1, 2].

The development to date has significantly influenced the first project of direct support for the purchase of vehicles with alternative drive. There was a positive impact on the growth of sales of electric vehicles and support was used by 831 applicants, the number of registered electric vehicles in 2017 increased year-on-year by 350%.

The measures of the Action plan are as follows:

- including the electromobility issues in all relevant national strategies and policies,
- continuity of direct support for the use of low-emission vehicles,
- long-term financial mechanism to support the development of charging infrastructure,
- support of research, development and production of batteries,
- information campaign,
- implementation of legal, technical and business environment for electromobility in Slovakia,
- accelerated depreciation of electric vehicles and charging stations for electric vehicles,
- applying the principles of green public procurement to the purchase of motor vehicles,
- differentiable marking of electric vehicles,
- use of dedicated lanes by electric vehicles,
- low emission zones,
- simplification of the administrative process for the construction of charging infrastructure,

DOI: 10.26552/tac.C.2020.1.2

- legislative introduction of the obligation to build charging infrastructure during the construction of new parking places,
- installation of charging station at the parking places of state institutions,
- adaptation of the qualification in the area of electrical engineering for the production and servicing of electric vehicles.

3.2.5 of Revision and actualisation of National political framework for the development of alternative fuels market [10]

The document presents the state of implementation of the measures of the National political framework [7]. In terms of electromobility, the measures are largely fulfilled. One measure (ensuring information ...) is fulfilled or fulfilment lasts respectively and fulfilment of one measure is still ongoing (education at schools ...). The document also defines new measures for the National policy framework, but in the field of electromobility, in regard to the adopted Action plan, does not propose further concrete measures.

4. Attitude of municipalities to the systemic dealing with electromobility

4.1. Electromobility in cities

Big analyses from charging stations point to clear segmentation of users. In principle, it is possible to identify groups of users who charge BEV or PHEV at home, at work, charging specifically associate with other activities (shopping, culture, sport, ...) or while travelling (i.e., for distances longer than the electric range what typically concerns inter-urban journeys) [11].

Therefore it is evident that a significant proportion of BEV and PHEV users utilise the infrastructure at the place of residence, work or civic amenities. Furthermore, taking into account that already available electric vehicles are suitable for urban or regional transport, either for individual car transport or urban public transport (e-bus), service systems, etc., it is clear that electromobility in urban conditions is legitimate. The municipalities should, therefore, respond to this trend and deal within its competences conceptually, but taking into account local specificities.

4.2. Attitude of municipalities

In terms of solving of transport and mobility issues, smaller municipalities in the Slovak Republic are undersized in terms of personnel and in many cases do not have professionally competent capacities. Therefore it is in the interest of the municipality to address such a professional issue as conceptual design of electromobility in cooperation with external capacities that will bring a different perspective on the state, problems and processes in the municipality.

Local authorities' attitude to systemic and conceptual solutions of the electromobility issues varies considerably. In many cases, municipalities have not yet tackled this problem conceptually, but principally, larger municipalities are more concerned with electromobility.

Tab. 1 provides an overview of examples of how selected municipalities have dealt with the issue of electromobility.

The most successful municipalities in the conceptual approach of electromobility were the municipalities involved in the solution of projects in the framework of international projects or interest associations (e.g. clusters). There is the added value of sharing knowledge and experience on a larger scale.

It is also evident that the attitude of cities has changed over time (see the example of Bratislava), similarly as the attitude of the government has been changing.

Generally, it can also be seen that the municipalities did not take into account the effective national framework for electromobility analysed above.

The quality of output - conceptual or strategic document - depends not only on the expertness of the stakeholders or subjects but also the available databases. The availability of data for its elaboration is usually closely related to the availability of other fine and relevant documents of the city and region, covering mainly the area of transport and economic and social aspects (Plan of economic and social development, Transport masterplan, Zoning plan, Sustainable urban mobility plan, Sustainable energy action plan, Cycling strategy, ...).

4.3. A good practice example

A good example of attitude to electromobility at the level of self-government is the Municipality of Senec. Municipality of Senec actively joined in the Interreg Danube Transnational Program by the Electric, Electronic and Green Urban Transport Systems (eGUTS) project [29], which aimed to develop a Local Action Plan (LAP) for the Municipality of Senec.

The process of LAP development consisted of several areas [25]:

- analysis of relevant documents at the national, regional and local levels,
- analysis of the current situation in the area of (e-)mobility, transport infrastructure and related areas,
- meetings, training, brainstorming,
- communication (phone calls, e-mail, teleconference, shared storage).

It should be noted that during the preparation of LAP only Plan of economic and social development and partially Zoning plan (in the process of changes) were available from the site of Municipality of Senec. The development of the Transport masterplan was interrupted at that time due to major changes in the infrastructure in the neighbourhood of the city. For this reason, face-to-face meetings with the responsible staff of the Municipal office were important, and they provided information to the authors of LAP that were not captured by any documents and materials. The LAP was prepared for the Municipality of Senec as a document with two parts - analytical and proposal ones - and annexes.

Table 1. Strategic and conceptual documents dealing with the electromobility of Slovak municipalities

Municipality	Document [Year of adoption]	Measure/activity/tool/project intention/target related to electromobility	Framework linkage	Ref.
Košice	Košice development program for 2015-2020 (2025) [2015]	● Increasing the capacity of parking places and its regulating in the central urban zone and housing estates – favouring of low-emission vehicles (BEV, PHEV) in the static traffic management system, ● Reducing of particulate matter in the city - promoting alternative mobility, including electromobility in the city	No linkage	[12]
Bratislava	Development of electromobility in the environment of the Slovak capital Bratislava [2013]	● Gain sufficient experience from electric vehicle fleet operation ● Modify pedestrian precinct access policy for traffic supply ● Active attitude to legislative changes ● Create 30 additional free parking spaces reserved only for EV in city centre ● Modify capacity assessment methodology for new investment construction Note: the document assumes the adoption of the Municipality's strategy to promote electromobility	No linkage – adopted before Framewok	[13]
Bratislava	Action plan on adaptation to the adverse consequences of climate change in the capital of the Slovak Republic Bratislava for 2017-2020 [2017]	● Support of electromobility in the city	No linkage	[14]
Michalovce	Economic and social development program of the Municipality Michalovce for 2016-2025 [2016]	● Electromobility of municipal police officers	No linkage	[15]
Žilina	Low carbon mobility action plan in the City of Žilina and its urban area [2017]	● Short and medium-term solutions (1 to 5 years): Implementation of e-bike sharing, Deployment of a low carbon zone within the 1st Urban Ring and adjustment of parking policy (low carbon places), Introduction of e-buses in urban transport, Installing Charging Stations Step 1 , Installing charging stations on the public lighting system ● Long term solutions (10-20 years): Expansion of (e)bike sharing, Introduction of e-car sharing, Expansion of low carbon zones, Introduction of e-bus charging stations at public transport stops (access to other areas), Introduction of WET charging at parking spaces, Realization of accumulation points (energy HUB)	No linkage	[16]
Bratislava	Smart City Bratislava 2030 - Smart City concept [2018]	● Development of emission-free and low-emission transport, ● Introduction of modern energy-saving and environmentally friendly technologies in the urban infrastructure, ● Partnership of the city with commercial entities, research organizations and public institutions	No linkage	[17]
Žilina	Concept of development of electromobility in Municipality of Žilina [2018]	● Charging infrastructure, ● Low-emission zones, ● Information system of electromobility	Strategy [6]	[18]
Association of municipalities	Joint development program of the Municipalities of region Oravské podhradie [2015]	● Development of electromobility in Orava region	No linkage	[19]
Poprad	Development program of the Municipality of Poprad for 2016 - 2022 with the outlook to 2040 [2015]	● Greening of transport through the development of non-motorized transport in the city in combination with the use of ecological fuels in public transport (electromobility), ● Note: the document assumes the adoption of the concept of development of alternative transport modes and electromobility	No linkage	[20]
Prešov	Development program of the Municipality of Prešov for 2015 - 2020 with the outlook to 2025 [2016]	● Increasing the share of electromobility in public transport, ● Equipping/supplementing the municipal police fleet with alternative CNG, LPG, electric vehicles/bicycles	No linkage	[21]
Bardejov	Smart City Bardejov [2019]	● The need for renewal of the public lighting system and its use for fiber optic network and electromobility ● Identification of the need to develop an (local) action plan for electromobility	Action Plan [9]	[22]
Nitra	Smart City - Smart and modern Municipality Nitra [2018]	● Deploying of a network of charging stations ● Development of electromobility - public transport ● Development of electromobility - individual transport ● Car sharing - system of public electric vehicles	No linkage	[23, 24]
Senec	Local Action Plan of e-mobility for Municipality of Senec [2019]	● Municipality policy updates, ● Indirect support of electromobility, ● Education, information and promotion of electromobility, ● The green procurement principle of the municipality and its entities, ● Support of electromobility infrastructure and services	Yes [6-10]	[25]
Lučenec	Audit of Municiplaty of Lučenec for the involvement in the Smart City program [2019]	● Consider supporting the development of electromobility in connection with the reduction of individual traffic in the centre, focusing on green public transport ● Infrastructure of the public lighting system is suitable for making electromobility accessible to residents (current infrastructure enables only slow charging) ● Municipality will consider upgrading the infrastructure for electromobility or the construction of parking houses	No linkage	[26]
Pezinok	Concept of ICT development in the Municipality of Pezinok [2019]	● Introduction of electromobility in the city (the basics of electromobility should be created by combining bike sharing and creating a network of charging stations for electric vehicles).	No linkage	[27]

DOI: 10.26552/tac.C.2020.1.2

The following parts are part of the analytical part:

- electromobility in the European context, trends in the EU, EU legislative and strategic framework,
- electromobility in Slovakia, policy framework and strategic documents of the Slovak republic,
- City of Senec, general characteristics of the city and its surroundings, statistical indicators,
- transport in the City of Senec, the fleet of Municipality of Senec, public transport,
- traffic in Senec and its surroundings, basic data on the road network, accessibility in Senec, road network load, road network load prospectively,
- externalities induced by transport, the contribution of electromobility to reducing emissions,
- development of electromobility, analysis of the economy of electric vehicles.

Within the proposal part, framework measures have been identified (see Table 1), each of which consists of sub-actions that specify the activities. The description of each measure was defined by the format negotiated within the eGUTS project consortium (Reference number, Action/Project name, Strategic document identification, Action/project description, Timeframe, Costs estimation/budget, Financing sources, Potential risks and barriers, Mitigation measures, Estimated impact, Project stages, Action/project holder/responsible department, Project custodian). For each of the measures, a detailed timetable for the project phase level (Gantt chart) and an explanation or comment is presented as well.

5. Improving the readiness of municipalities

From the above mentioned follows that most municipalities are generally not sufficiently prepared for the development of electromobility due to personal and know-how reasons.

The following steps could improve the situation:

- centralising of information at national level on a single website,
- consultancy from the Ministry of Economy,
- taking part of municipalities in (international) projects or associations (clusters),
- cooperation with professional commercial subjects and citizens association (NGOs, action groups, voluntary organizations, ...) operating in the region in the field of electromobility,
- development of a comprehensive conceptual material (strategy, program, action plan, ...) for electromobility.

In this way, municipalities will achieve:

- access to information, best practices, trends,
- increasing of specialised competence and know-how,
- readiness for dynamically changing conditions,
- readiness for possible involvement in projects, grants and subsidy schemes (and thus to implement projects with a small share of own resources),
- possibility to build a functional ecosystem of electromobility.

5. Conclusions

The article analyses the national framework for electromobility in the Slovak Republic, which was established under the auspices of the Ministry of Economy of the Slovak Republic and where measures and objectives are defined, which have gradually begun to be implemented from the national level. The development of electromobility will depend not only on the consistency of state policy but also on how the municipalities will deal with this issue.

Experiences show that the approaches at the level of municipalities are very heterogeneous and, in case of lack of active attitude of municipalities, there may also occur excesses in the future (e.g. excess of demand for charging, insufficient infrastructure for charging station development, ...). Therefore it is necessary for cities to be prepared for the development of electromobility and to be able to respond adequately to the changing conditions. It can be expected that without a more proactive attitude of municipalities, the issue of electromobility will be conceptually solved insufficiently and the problems the municipalities will face will be dealt ad-hoc.

ACKNOWLEDGEMENTS

"This publication was realized with support of Operational Program Research and Innovation in frame of the project: ICT products for intelligent systems communication, code ITMS2014+ 313011T413, co-financed by the European Regional Development Fund"

REFERENCES

[1] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure

[2] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources

[3] M/468 Standardisation mandate addressed to CEN and CENELEC and ETSI concerning the charging of electric vehicles

[4] M/453 Standardisation mandate addressed to CEN, CE-NELEC and ETSI in the field of information and commu-nication technologies to support the interoperability of co-operative systems for intelligent transport in the Euro-pean community

[5] M/490 Smart Grid Mandate Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment

[6] Slovak government resolution No. 504/2015 on Strategy of electromobility development and its effect on Slovak economy (Original in Slovak).

[7] Slovak government resolution No. 504/2016 on proposal of National political framework for development of alternative fuels market (Original in Slovak).

[8] Slovak government resolution No. 505/2016 on proposal of National policy of deployment of infrastructure for alternative fuels in conditions of the Slovak republic (Original in Slovak).

[9] Slovak government resolution No. 110/2019 on proposal of Action plan of electromobility development in the Slovak republic (Original in Slovak).

[10] Slovak government resolution No. 557/2019 on proposal of Revision and actualisation of National political framework for development of alternative fuels market (Original in Slovak).

[11] Čuboň, P., Hrudkay, K.: Systemic attitude to electromobility in Smart City concept, Proceedings of the conference Traffic Engineering 2017, Zilina (Original in Slovak), 2017.

[12] Košice development program for 2015-2020 (2025) [Online], Available: www.kosice.sk/mesto/program-rozvoja-mesta-kosice-na-obdobie-rokov-2015-2020 [2 Apr. 2020], 2015. (Original in Slovak),

[13] Development of electromobility in the environment of the Slovak capital Bratislava [Online], Available: https://zastupitelstvo.bratislava.sk/data/att/34316.pdf [2 Apr. 2020], 2013. (Original in Slovak).

[14] Action plan on adaptation to the adverse consequences of climate change in the capital of the Slovak Republic Bratislava for 2017-2020 [Online], Available: https://zastupitelstvo.bratislava.sk/data/att/14595.pdf [2 Apr. 2020], 2017. (Original in Slovak).

[15] Economic and social development program of the Municipality Michalovce for 2016-2025 [Online], Available: www.michalovce.sk/sk/clanok/strategicke-dokumenty [2 Apr. 2020], 2016. (Original in Slovak).

[16] Low carbon mobility action plan in the City of Žilina and its urban area [Online], Available: www.zilina.sk/strategicke-dokumenty-mesta/ [2 Apr. 2020], 2017. (Original in Slovak).

[17] Smart City Bratislava 2030 - Smart City concept [Online], Available: https://zastupitelstvo.bratislava.sk/data/att/38524.pdf [2 Apr. 2020], 2018. (Original in Slovak).

[18] Concept of development of electromobility in Municipality of Žilina [Online], Available: www.zilina.sk/strategicke-dokumenty-mesta/ [2 Apr. 2020], 2018. (Original in Slovak).

[19] Joint development program of the Municipalities of region Oravské podhradie [Online], Available: www.oravskypodzamok.sk/download_file_f.php?id=694564 [2 Apr. 2020], 2015. (Original in Slovak).

[20] Development program of the Municipality of Poprad for 2016 - 2022 with the outlook to 2040 [Online], Available: https://mobil.poprad.sk/download_file_f.php?id=685083 [2 Apr. 2020], 2015. (Original in Slovak).

[21] Development program of the Municipality of Prešov for 2015 - 2020 with the outlook to 2025 [Online], Available: www.presov.sk/prm-presov-2015-2020.html [2 Apr. 2020], 2016. (Original in Slovak).

[22] Smart City Bardejov [Online], Available: http://www.bardejov.sk/mestsky-urad/strategicke-a-rozvojove-dokumenty-mesta/koncepcie-a-phsr [2 Apr. 2020], 2019. (Original in Slovak).

[23] Smart City - Smart and modern Municipality Nitra, Material for the City Council in Nitra of 15.12.2016 [2 Apr. 2020], 2016. (Original in Slovak).

[24] Concept Smart City of the Municipality of Nitra [Online], Available: http://www.smartcityvpraxi.cz/prezentace/Konference_SmarcityvpraxiIII/Jozef_Dvonc_2018.pdf [2 Apr. 2020], 2018. (Original in Slovak).

[25] Local Action Plan of e-mobility for Municipality of Senec [Online], Available: www.senec.sk/sk/clanok/uzemny-plan [2 Apr. 2020], 2019. (Original in Slovak).

[26] Audit of Municiplaty of Lučenec for the involvement in the Smart City program [Online], Available: www.lucenec.sk/strategicke-dokumenty-mesta.phtml?id3=130460 [2 Apr. 2020], 2019. (Original in Slovak).

[27] Concept of ICT development in the Municipality of Pezinok [Online], Available: www.pezinok.sk/uploadfiles/File/msz/2019-11-28/MsZ_PK_2019-11-28-bod08.pdf [2 Apr. 2020], 2019. (Original in Slovak), 2019.

[28] Madleňák Radovan, Madleňáková Lucia, „Application of OSI reference model to the logistic systems“, In: Archives of transport system telematics, pp. 35-39, 2016.

[29] Electric, Electronic and Green Urban Transport Systems, [Online], Available: www.interregdanube.eu/approved-projects/eguts [2 Apr. 2020], 2020.

Transport and Communications, 2020; Vol. I.
ISSN: 1339-5130
DOI: 10.26552/tac.C.2020.1.3

Online Consumer Purchasing Behaviour in Slovakia

Dominik Laitkep[1], Edgars Červkovskis[2]

[1]Department of Communications, University of Žilina, Žilina,010 26, Slovakia
[2]Department of Business, Europe Distance Education Secondary School, Riga, LV-1019, Latvia

Abstract The paper describes buying behaviour of Slovak consumers who use social networks. Knowledge of consumer behaviour and consumer preferences means a competitive advantage in the business environment, which is a complex process with many variables. The aim of this study is to present the results of the author's primary research, processed by reducing the number of variables by applying factor analysis. Research shows that consumers are used to making decisions about their purchases directly on the Internet and they using all available information. For Slovak consumers are online order payment together with free delivery important factor for making a purchase in the Slovak e-commerce environment. Another key factor for making purchases are impulses from social networks and the option to purchase through the mobile app.

Keywords Purchasing behaviour, E-commerce, Factor analysis, Social networks, Slovak consumers

JEL M39, L81, R19

1. Introduction

Consumer buying behaviour includes behaviour of individuals as well as households. Consumers make decisions whether or not to buy on a daily basis while responding to different incentives. These incentives include product, price, method of acquisition as well as various marketing elements such as advertising and various discounts. Based on these incentives, consumers decide where and what to buy and due to satisfy their needs.

Philip Kotler, defines customer needs as state of felt deprivation of some basic satisfaction. Consumer behaviour can be determined by Kulčáková M. and K. Richter as consumers behaviour when purchasing, using, searching for and evaluating products and services when they expect to meet their needs. [2] [3]

On the other side of needs stand enterprises, which one of the strategic objectives is to generate profit. We know several objectives, which are the basis for evaluating the business and measure for success or failure. "*Goals are for management and other management level commitment to achieving concrete results at a particular time."* [1] If a company is unable to set goals correctly, then it is unable to develop a strategy. In order to meet these goals, businesses today mainly use online marketing communication tools along with social networks.

According to the authors Králiček and Kráľ we understand marketing communication particularly as promoting business for specific target groups, which fulfils not only marketing but also strategic goals.[4] Another definition regards marketing communication as a influencing protentional customer purchase. [5]

If marketing communication and various supporting attributes are correctly applied, it means premise to improve the market position with increase of enterprise revenue and profit.

2. Analysis of current state

We focused on areas of social networks, the basic attributes of marketing communications, as well as the possibility of payment for goods and services, but also a new trend, which are influencers.

Smith defines the social network as an association of communities or groups of people who share a common interests. [7] Social networks popularity these days also brought opportunities for enterprises as affecting users in their communication and decision-making.

Users of social networks are learning from each other, participating in various discussions and they are exposed to various influences by ads which are affected in the process of purchasing. [8]

2.1. Attributes influencing shopping behaviour

Marketing communication, through promotional tools like social networks provides information and convincing bases for target consumers. It works as a "stimulus" that can trigger the decision-making process of buying and also helps to make more informed decisions for consumers. It is important to note that marketing communications through online promotion tools are just one of the attributes. [9]

One of the newest attributes are influencers on social networks. Influencers represent a new type of popular people, who form the attitudes of the audience and their followers through blogs, status and other forms of promotion on social networks. [6]

Popular social networks from promotional tools include:

- **Facebook and Instagram** - With nearly 2.3 billion active monthly users, Facebook is one of the most important platforms;
- **Twitter** - With 326 million active users each month, Twitter is almost impossible for companies to ignore, and most of the businesses are active in it;
- **LinkedIn** - LinkedIn is a social media platform, exclusively for business;
- **Newsletter** - Email promotion is still the number one of online communication tool;
- **Website** - The site's role is to provide the necessary information instantly and effortlessly. [12]

By combining different tools of communication through are enterprises promoted, they can gain the best position in the market. By adding various payment options and also providing different forms of transport of purchases, it gives enterprises the opportunity to move closer to their customers wishes. [10]

The e-commerce market also contains other attributes that we have included in our research and can be seen in Table 1.

Table 1. Attributes from primary research

Number	Attributes
1.	Importance of social networks
2.	The quality of the content on social networks
3.	Truthfulness of the social network content
4.	The importance of influencers
5.	Influencer's option
6.	Promo codes form influencers
7.	Sales actions
8.	Promo codes for first purchase
9.	Companies activities on social networks
10.	Purchasing in store
11.	Online purchasing
12.	Website design
13.	Impulsive shopping
14.	Delivery methods
15.	Free delivery
16.	Offline advertising
17.	Purchase through apps
18.	Suinstable business
19.	YouTube business activities
20.	Business reviews
21.	Purchasing in known company
22.	Cash payment
23.	Online payment
24.	Crypto payment
25.	Newsletter

The table show attributes covering areas such social networks, sales promotions and online and offline advertising.

3. Methodology

The aim of the article was to identify individual attributes and subsequently to determine the extent to which of these attributes influence the purchasing behaviour of customers in the Slovak Republic the most. To achieve this goal, it was necessary to use methods such as the method of excerpting, the method of analysis, primary research, factor analysis, the method of induction and deduction. In conducting the primary survey, we managed to reach up to 1814 respondents, social network users aged 15 to 64 years. Questions from primary survey are the attributes contained in Table 1. The survey was conducted at the end of 2019 in November. To calculate the minimum sample size, it was necessary to find out how many people in the SR have a target age. At the date of 01. 07. 2019, the population over 15 years to 64 old in the Slovak Republic is 3,662,779. [11] After finding the number of residents, we used the following formula for the calculation of the basic files:

$$n \geq t_{1-\frac{\alpha}{2}}{}^{2} * \frac{\sigma^{2}}{\Delta^{2}}$$

where:

n - is the minimum sample size (minimum number of respondents),

t_(1-α/2) - s the critical value determined from the tables (critical values of the normalized normal distribution),

σ2 - is the spread calculated from the standard deviation,

Δ - is the maximum allowable margin of error.

Then we put the values into the formula:

$$n \geq \frac{1{,}96^{2}}{0{,}03^{2}} \text{x}\ \ 0{,}5^{2} = 1067{,}11 \doteq 1068 \ \ \text{respondents}$$

After substituting the values into the formula for the large sample population calculation, we found that at a 95% confidence level and a 3% error margin, the minimum sample size was 1068 respondents. We fulfil our sample with 1814 respondents. After fulfilling our sample we used factor analysis to evaluate the results of the primary research, where eight factors were identified. Factor analysis was realized on the platform of opensource software solution PSPP. [13]

4. Results

Based on the results from PSPP software presented in the rotated factor matrix shown in Figure 1, it is possible to interpret the outputs. For better interpretation it is necessary to understand the rotation of factors. After the rotation is applied, it is possible to identify the correlation values for the individual factors and define them, so that the load of that factor can be identified by the relevant variable. The values of the correlation coefficient reaches a value ranging from -1 to +1, -1 which is the most possible negative correlation and +1 highest positive correlation. A value of 0 represents a zero correlation.

DOI: 10.26552/tac.C.2020.1.3

In this case we proceed by sorting the relevant variables to the factors by assigning them to the factor by their highest value. The given rotational matrix shows the relationships between the variables. The factor matrix represents a matrix of identified factors and correlation values between identified factors 1 to 8. This is the main output of the factor analysis.

Rotated Component Matrix								
Atributes	Component							
	1	2	3	4	5	6	7	8
1. The importance of social networks	,07	,04	-,01	,26	,17	,71	,03	,15
2. The quality of the content on social networks	,05	,13	- ,02	,20	,27	,75	,01	0,6
3. Truthfulness of the social network content	-,06	,25	,05	,00	-,07	,62	-,02	,00
4. The importance of influencers	,30	,04	,04	,03	,84	,09	,00	,09
5. Influencer's opinion	,27	,08	,03	,12	,46	,20	,00	,75
6. Promo codes from influencers	,16	,06	,02	,40	,54	,21	,03	,22
7. Sales actions	,04	,11	-,02	,78	,11	,04	,05	,03
8. Promo codes for first purchase	,17	,16	,00	,65	,04	,20	,06	,02
9. Companies activities on social networks	,19	,09	-,01	,64	,01	,20	,00	,01
10. Purchasing in store	,14	-,05	,92	-,03	-,02	,04	-,12	,00
11. Online purchasing	-,05	,15	-,51	,19	,06	,04	,75	,02
12. Website design	,11	,49	-,22	-,04	,08	,21	,14	,04
13. Impulsive shopping	,31	,03	-,19	,33	,37	,00	,12	,23
14. Delivery methods	-,13	,60	-,01	,15	-,08	,11	,03	-,04
15. Free delivery	-,03	,48	,10	,26	,08	-,11	-,04	,06
16. Offline advertising	,54	,02	,20	,17	,05	,08	-,14	,00
17. Purchase through apps	,27	,09	-,22	,15	-,16	,40	,14	-,14
18. Sustainable business	,49	,24	,00	-,24	-,15	,24	,03	-,08
19. YouTube business activities	,58	,11	-,01	,07	,22	,09	,05	,10
20. Businesses reviews	,08	,62	-,07	-,04	-,04	,21	,04	-,01
21. Purchasing in known company	,06	,63	,04	,07	,06	,11	,03	,04
22. Cash payment	,05	,35	,35	,10	,08	-,07	-,19	,03
23. Online payment	,18	,24	-,22	,14	-,22	,17	,15	-,12
24. Crypto payment	,58	-,14	-,05	,11	,16	-,17	,04	,10
25. Newsletter	,58	-,03	,06	,33	,16	,02	-,01	,05

Figure 1. Output from PSPP software - Rotated component matrix.

In the case of variable number 22 we assign the variable to factor number 3 as it achieves the same value in factor 2 but due to the nature of the question it is more inclined to include factor 3.

4.1. Factors reduction

Based on the results presented in the rotated factor matrix, it is possible to interpret the outputs. It can be stated that all variables affect respondents when buying, each of which has a different importance. We found that the dependence between attribute variables can be characterized by reducing variables to eight factors. All attribute variables positively correlate with factors.

4.1.1. Factor No. 1.

Factor number 1 contains variables whose acquired value is from 0.49 to 0.58. Factor No. 1 represents a combination of variables such as offline advertising together with YouTube activities and the existence of newsletters advertising and crypto paying.

4.1.2. Factor No. 2.

Factor number 2 contains variables whose acquired value is from 0.49 to 0.63. Factor No. 2 represents a combination of variables such as online payment, delivery methods, business reviews and website design. Based on the results of determination of signification value shown in table number 2., it can be confirmed that this is a minor factor affecting the customer when they making a purchase.

4.1.3. Factor No. 3.

Factor number 3 contains variables whose acquired value is from 0.35 to 0.92.. Factor No. 3 represents a combination of variables such as purchasing in store together with cash payment.

4.1.4. Factor No. 4.

Factor number 4 contains variables whose acquired value is from 0.64 to 0.78. Factor No. 4 represents a combination of variables such as sale actions together with promo codes for first purchase and the existence of company activities on social networks.

4.1.5. Factor No. 5.

Factor number 5 contains variables whose acquired value is from 0.37 to 0.84. Factor No. 5 represents a combination of variables such as impulsive shopping together with impulses for purchasing from influencers.

4.1.6. Factor No. 6.

Factor number 6 contains variables whose acquired value is from 0.40 to 0.75. Factor No. 6 represents a combination of variables such as using of importance of social networks together with purchasing through apps.

4.1.7. Factor No. 7 and No. 8

Factor number 7 contains only one variable which acquired value is 0.75. Factor No. 7 represents online purchasing variable.

Factor number 8 contains only one variable which acquired value is 0.75. Factor No. 8 represents Influencers opinion variable.

4.2. Determination of signification value

For transformed factors 1 to 8, a significance value was determined which evokes the importance of influencing them in the purchase. The most important is the one with highest value.

Table 2. Determination of signification value

Serial No.	Factor	Significance value
1.	No. 2	[(3,54+4,1+3,67+3,85+3,60+3,70)/6] = **3,74**
2.	No. 6	[(3,15+3,18+4,24+3,33)/4] = **3,47**
3.	No. 3	[(3,05+3,34)/2] = **3,22**
4.	No. 7	[(3,19)/1] = **3,19**
5.	No. 4	[(2,76+2,78+2,78)/3] = **2,77**
6.	No. 1	[(2,29+3,40+2,06+1,41+1,96)/5] = **2,22**
7.	No. 8	[(2,03)/1] = **2,03**
8.	No. 5	[(1,76+2,34+1,73)/3] = **1,96**

The table number 2. shows the significance values of these factors. The determination of materiality was based on the average values determined using the liquor scale in the realized primary survey.

5. Conclusions

Based on the presented research and the results of the factor analysis, it is possible to express that the purchasing behaviour of Slovak customers which are using social networks is influenced mainly by traditional and already used tools.

These tools are a design website, delivering methods with an ordering for free along with online payment. Reviews of online businesses and shopping from well-known businesses are also important. This result proves that, online communication tools are still have the greatest impact on the buying behaviour of customers. For customers are also important social networks and truthfulness of published posts.

For enterprises, it is very important to use all tools and the opportunities that the Internet provides. The results reveal interesting findings in relation to the mutual correlation between the examined variables. The results also reveal their significance in terms of their impact on customer purchasing behaviour and the achievement of the enterprises on the turbulent market.

REFERENCES

[1] SLÁVIK, Š. 2005. Strategický manažment. Bratislava: SPRINT, 2005. 403 s. ISBN 80-89085-49-0. s. 48.

[2] KOTLER, Ph.: Marketing management. Praha : Grada Publishing, 1998. 710 s. ISBN 80-7169-600-5.

[3] KULČÁKOVÁ,M., RICHTEROVÁ, K.: Spotrebiteľské správanie (Vybrané kapitoly). Bratislava : Ekonóm. 1996, s. 6.

[4] KARLÍČEK, M., KRÁL, P. Marketingová komunikace: jak komunikovat na našem trhu. 1. vyd. Praha: Grada, 2011, 213 s. ISBN 978-80-247- 3541-2.

[5] HESKOVÁ, M., ŠTARCHOŇ, P. Marketingová komunikace a moderní trendy v marketingu. 1. vyd. Praha: Oeconomica, 2009, 180 s. ISBN 978-80-245-1520-5.

[6] Gorry, G. A., & Westbrook, R. A. (2009). Winning the internet confidence game. Corporate Reputation Review, 12(3), 195–203.

[7] SMITH, A. N., FISCHER, E., YONGJIAN, CH. How Does Brand-related User-generated Content Differ across YouTube, Facebook, and Twitter?. Journal of Interactive Marketing [online]. 2012, vol. 26, issue 2, s. 102-113

[8] SABATE, F., BERBEGAL-MIRABENT, J., CAÑABATE, A., LEBHERZ, R. Factors influencing popularity of branded content in Facebook fan pages. European Management Journal [online]. 2014, vol. 32, issue 6, s. 1001-1011

[9] LI, Y., LAI, CH., CHEN, CH. Identifying bloggers with marketing influence in the blogosphere. In: Proceedings of the 11th International Conference on Electronic Commerce - ICEC '09 [online]. New York, New York, USA: ACM Press, 2009, s. 335, ISBN 9781605585864.

[10] Belch, G. E., & Belch, M. A. (2011). Advertising and Promotion: An Integrated Marketing Communications Perspective (9th ed.). McGraw-Hill Education.

[11] Vekové zloženie – SR, oblasti, kraje, okresy, mesto, vidiek. (2020). STATdat.

[12] Search engine journal - The 7 Biggest Social Media Sites in 2020. Avaible: <https://www.searchenginejournal.com/social-media/biggest-social-media-sites/#close>.

[13] Statistika PSPP. Dostupné na internete: < https://statistikapspp.sk/softver-pspp/>.

Transport and Communications, 2020; Vol. I.
ISSN: 1339-5130

The Use of Monte Carlo Simulation Method in Decision Support Via MATLAB Script

Viliam Mojský[1], Karol Achimský[1]

[1]Department of communications, Faculty of Operations and Economics of Transport and Communications, University of Žilina, Univerzitná 1, 010 26 Žilina, Slovakia

Abstract In our research we examined the possibility of using Monte Carlo simulation to support decision making through simulation models. For this purpose, we chose a basic economy task assignment. Subsequently, we created a simulation algorithm in Matlab, where we searched for the optimal amount of offered products based on the task inputs. The output of the research is a simulation algorithm using the Monte Carlo method to solve a given economic problem.

Keywords simulation methods, Monte Carlo, Matlab, decision support

JEL C63

1. Introduction

Simulation allows us to simulate the behaviour of the real system via a created model. Using this model, it is possible to simulate various events that may occur. Based on the simulation results, it is possible to estimate with some probability the development of the real situation. Simulation and simulation models are powerful tools that can help us with decision making, with the right inputs. The correctness of these models is influenced by the correct determination of the relationships, functions and probabilities of events to be simulated.

In the research we dealt with the Monte Carlo simulation method. We applied this method to an example from the field of economics in which the method was used as a tool to support decision making between several eventualities. We used Matlab to create the simulation model.

2. Materials and Methods

The chapter briefly describes the theoretical background and the program we used to create the simulation.

2.1. Simulation, model, Monte Carlo

Simulation is the process of creating a model of a real system and conducting experiments with it to achieve a better understanding of the behaviour of the system studied, or to assess various variants of system. A system is a set of elements that are organized in a certain way. A real system is a part of the real world that is of interest. We can refer to the model as a guide or a system that provides, to some extent, the same behaviour as a real system [1,2].

The term model is used to refer to both material and immaterial imitation of an object, regardless of the purpose for which it is used. The imitation itself can be implemented with practical tasks, it can fulfil certain functions, or it can be used for research purposes [3,4].

The Monte Carlo method is called a numerical method of solving mathematical problems by modelling random variables and statistical estimation of their characteristics. The Monte Carlo method can be used to solve any mathematical problems, both stochastic and deterministic [5].

The Monte Carlo method is a numerical method based on the relationship between the probability characteristics of various random processes and the quantities that are the solution of the studied problems [6].

2.1. Matlab

Matlab is a programming platform for research and scientific purposes. It is based on Matlab's own programming language. It is a matrix-based language that allows to naturally express mathematical calculations. Matlab combines a working environment for iterative analysis and process design with a programming language that directly expresses matrices and mathematical fields. It is possible to analyse data, create algorithms and create models and applications using Matlab [7].

Matlab has several working environments. We have chosen Live Script. It is a new work environment that combines Matlab code with formatted text and image output in the Live Editor environment [8].

3. Results

At the beginning of the chapter is given an economic problem, for which we created a simulation model by Monte Carlo method in Matlab. After the task assignment, the flowchart and the individual parts of the simulation model are presented.

3.1. Task assignment

The post office manager is facing an uneasy task in the pre-Christmas period. Before Christmas, postcards with the wishes of "Merry Christmas and a Happy New Year" are sold well as ancillary goods. One postcard is purchased by the postal manager for 0.70 Eur and sold for 1.20 Eur. Postcards that are not sold by the end of the New Year period are then sold at a 50% discount. The difficult task of the postal manager is to decide how many postcards to order in order to maximize the profit from postcard sales. If the demand for postcards is higher than the quantity ordered, the post office will lose profits due to lack of postcards. Conversely, if the demand for postcards is lower than the quantity ordered, the post office will lose some of the profits due to the Christmas discount sale.

The profit equation if demand is greater than supply is:

$z = (1{,}20 – 0{,}70) * q$

If demand is smaller than supply, then the profit equation is:

$z = 1{,}20 * d – 0{,}70 * q + 0{,}60 * (q – d)$

The simulation model inputs are:

- Ordered quantity q (decision variable),
- Different income levels and expenditure factors (constants)
- Demand d (probability variable)

If demand is known, we can calculate the profit from the equations above. Because demand is probabilistic variable, we must choose the value of the demand from probability distribution of demand. We have defined the decision problem by assuming a level of demand from the range of 400-900, from which we will randomly select numbers using the randi function. This selects pseudo-random numbers from the given range according to an even distribution.

3.2. Flowchart

We have created a development diagram according to the given task assignment. The flowchart is shown in Figure 1.

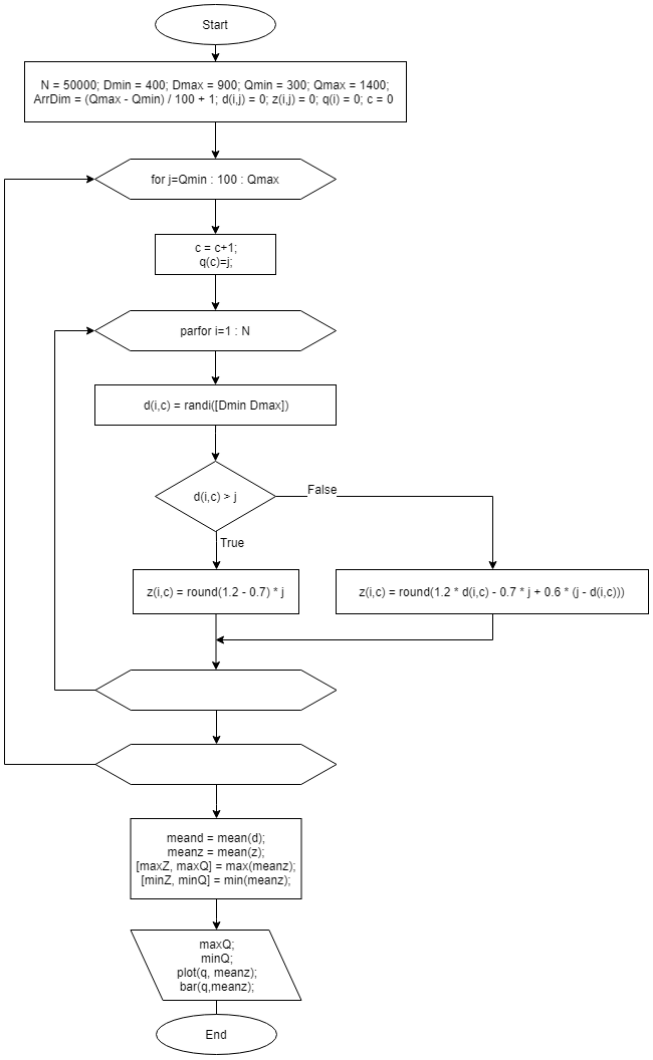

Figure 1. Algorithm flowchart

3.3. Simulation model in Matlab

Based on the flowchart, we started writing the algorithm code in Matlab. We created the code in Live Script. This allowed us to use some additional features, such as displaying outputs without opening additional program windows. Another advantage is that we can run the program on any computer through the Matlab cloud environment without the need to install Matlab.

The created program was divided into three logical parts. We decided for the three parts because they logically divided the program into inputs, algorithm operations and outputs. These parts are described separately in their own chapters. Parts of the source code used are listed in each chapter.

3.3.1. Initialization part

In initialization part are defined input variables, which are used in the program.

Source code:

```
clear;
tic;
```

DOI: 10.26552/tac.C.2020.1.4


```
N = 50000;
Dmin = 400;
Dmax = 900;
Qmin = 300;
Qmax = 1400;

ArrDim=(Qmax-Qmin)/100+1;
d = zeros(N,ArrDim);
z = zeros(N,ArrDim);
q(:,1) = Qmin:100:Qmax;
c = 0;
rng(47);
```

The clear function flushes the cache and all values from previous instances of this or another Matlab script. This ensures that past results do not affect the current instance. In addition to biasing the results, without flushing the cache, bugs could also be generated as a result of using variables from previous scripts. The clear function is followed by the tic function. This is a paired function, the pair to which is the toc function, located at the end of the source code. The tic toc function is used to measure the time required to execute a program. The measured time is displayed in the output window along with the other outputs. The function can be used multiple times in the program to determine which part of the program is the most time consuming and needs optimization. The function was mainly used during development. In the final version, it is used to compare how changing the size of input values affects the length of program execution.

Input variables follow. N denotes the number of repeats, i.e. the number of generated pseudo-random numbers that will be used in one iteration of the cycle. The value is set to 50,000, which we consider sufficient. Dmin and Dmax, which represent the minimum and maximum predicted dose, were also determined. They are used in the program as the lower and upper bounds of the range from which pseudo-random numbers are generated. Qmin and Qmax were set after them to set the minimum and maximum quantities offered. These are used in the first cycle as the minimum demand, to which 100 is added at each iteration until the maximum demand is reached.

After defining the input variables, the initialization section also contains commands for pre-allocation of variables. This is done to speed up the implementation of the program. In the program, fields are filled at each cycle iteration. Matlab can work faster with a field if it does not have to extend it each time it is filled, but simply overwrites the value at given field position. The number of columns in the array is initially determined. This value is stored in the ArrDim variable and is calculated by subtracting the maximum and minimum demand, dividing the result by 100 and adding 1 to it. Adding 1 is required because Matlab does not work with arrays like other programming languages. The initial value in the two-dimensional array has a coordinate of 1.1, unlike other programming languages, where the first coordinate value is 0.0. The result of this calculation is used for three successive populations of the variables d and z. Both are defined as two-dimensional arrays with dimensions N (number of rows) and ArrDim (number of columns). Generated predicted query is stored in variable d. The variable z stores the calculated profit based on the expected demand. Both variables are filled with zeros that are overwritten when the program executes. Each level of the ordered quantity has its own column in which the measured values are stored. Another variable defined is q. This is filled with levels of offered quantity from minimum to maximum, increasing by 100. Since we know that variable q will be a 1-dimensional vector, we have defined it as a column array with (:, 1) statement, instead of the default row array. We did this because of faster access to its values, because Matlab can work faster with column variables. This is an optimization approach in declaring variables. Next, the variable c has been defined to be zero. This variable provides the addressing of the correct column in the "d" and "z" fields used in the program. The last command is the rng function. This provides a seed for pseudo-random numbers, so that every time the simulation is repeated, we always get the same result. It is set to 47, a nonnegative integer that generates predictable pseudo-random numbers. If we always want a different result, we can set the value ‘shuffle‘.

3.3.2. Generating pseudo-random numbers

The next part of the program lists the cycles that ensure that a specified number of pseudo-random numbers will be generated. In the cycles there are also formulas from the example, which are placed in a decision statement, which, based on the input parameters, decides which of the formulas is used.

Source code:

```
for j=Qmin:100:Qmax
    c=c+1;

    parfor i=1:N
        d(i,c)=randi([Dmin Dmax]);
        if d(i,c)>j
            z(i,c)=(1.2-0.7)*j;
        else
          z(i,c)=1.2*d(i,c)-0.7*j+0.6*(j-d
          (i,c));
        end
    end

end
```

At the beginning of the code is a for loop. This ensures that the cycle runs in a predetermined number of iterations. In this case, it ensures the execution of orders inside, for each level of ordered quantity separately. It starts with the minimum order quantity and increases in 100-increments up to the maximum order quantity. This is followed by a command that increases the value of c. This ensures that each level of ordered quantity will have its own column index. This is followed by the parfor command. This is a

parallel for command. Parallelization means that the command can be executed in parallel, or simultaneously, with other commands. This is a very useful method that can significantly speed up program execution. By default, the program is run on a single thread. Multiple processor threads can be utilized through parallelization. This means that on multi-core and multi-threaded processors, the program will run significantly faster. However, we need to be very careful about what processes we parallelize, because improper use can cause errors in the program, which may not occur immediately during testing. The parfor cycle runs N times for i from 1 to N. In our case, N is 50,000, so the cycle runs 50,000 times. It is important that the variables that have been produced in the parfor are indexed. This prevents errors such as overwriting variables. For example, a pseudo-random number d (i, c) could cause a serious program error without an index. This is because every new iteration of the cycle generates a new pseudo-random number. If the program runs on 4 threads, the number d would be generated 4 times. Since generating is the first operation within a cycle, the last generated number d would be stored in variable d. This number would continue to be used in the cycle and could be changed again while running because the threads are working at the same time. In this case, the results would be significantly distorted and rendered irrelevant. Therefore, the variable d is indexed, ensuring that each iteration of the cycle has its own number d, to which it assigns its own pseudo-random number with which the cycle works and no further iteration can change it. It is important that the index changes with the cycle iteration. If it were changed by calculation, it could lead to errors again. In this case, the index changes according to the variable i, which is defined in the parameters of the parfor cycle, which ensures its security. The body of the cycle also contains the variable j, which does not have an index. However, this is fine, this variable is invariant for all iterations of the parfor cycle. Its value is determined by the parent for loop. In the parfor cycle, it is used only in calculations, which is logically correct. The variable c is similar. The last variable in the parforum cycle is the variable z (i, c), which again changes its value at each iteration. Its calculation depends on the result of the decision order. This variable is also indexed to avoid errors in the program.

Within the parfor cycle, pseudo-random numbers are generated and evaluated. The profit is then calculated. The first command generates a pseudo-random number via the randi function. This generates numbers from the range given by the minimum and maximum predicted demand, according to the even distribution. The generated number is stored in the variable d (i, c). Subsequently, the number generated is equal to the level of the ordered quantity j via the if statement. If the result of the comparison is true, the generated number is greater than the quantity ordered, i. the demand is larger than the offer, then the if statement is executed. If the result of the comparison is not true, so the offer is greater than the demand, then is executed the else branch. Both formulas in the if statement are taken from the assignment. Their task is to calculate the profit based on the result of the comparison of demand with offer. The calculated gain is stored in the variable z (i, c). The profit calculation is followed by the end of the if decision statement and both cycles are followed by end keywords.

3.3.3. Algorithm outputs

Outputs from the model are divided into two parts, namely text part and graphic part. Text outputs generates sentences indicating maximum and minimum values. Graphical outputs contain several variants of possible Matlab outputs.

Text outputs

Source code:

```
meanz(:,1)=round(mean(z),2);
[maxZ,maxQ] = max(meanz);
[minZ,minQ] = min(meanz);

odpoved1 = ['Najväčší zisk bude pravdepodobne
dosiahnutý pri ponúkanom množstve
',num2str(q(maxQ)), 'ks vo výške '
,num2str(maxZ),'€.'];
disp(odpoved1);
odpoved2 = ['Najmenší zisk bude pravdepodobne
dosiahnutý pri ponúkanom množstve
',num2str(q(minQ)), 'ks vo výške '
,num2str(minZ),'€.'];
disp(odpoved2);
```

At the beginning of the code is defined the meanz variable, which is a one-dimensional array. Again, to optimize performance, it is defined as a column vector by the (:, 1) statement. This variable stores the calculated average value for each column from the profit field of (i, j). The results are rounded to two decimal places. In the next two commands, its maximum and minimum (maxZ and minZ) as well as their position in the array (maxQ and minQ) are determined from the meanz field. Writing the generated variables in square brackets is necessary because the value and position of the search value in the array is determined.

In the answer1 statement, a text response is formulated by string interpolation. The variables had to be modified before being inserted into the sentence. These are numbers, so they are of type number and must be converted to a string with the num2str function to be inserted into a sentence. The first number is read from the field q (i), where "i" is replaced by the detected maxQ variable, which represents the position of the maximum quantity. The second number is the maxZ variable, which is also converted to a string. The disp function is used after the generated responses to display the generated sentences. For minimum values, the same procedure was used, but with different values. The resulting outputs are shown in Figure 2.

Graphic outputs

Source code:

```
xaxmin = Qmin-Qmin*0.2;
```

DOI: 10.26552/tac.C.2020.1.4


```
  xaxmax = Qmax+Qmax*0.05;
  yaxmin = minZ-minZ*0.2;
  yaxmax = maxZ+maxZ*0.1;

plot(q,meanz,'-s','MarkerSize',5,'MarkerEdg
eColor','red','MarkerFaceColor',[1 .6 .6]);
hold off;
axis([xaxmin xaxmax yaxmin yaxmax]);
ylabel('Priemerný zisk');
xlabel('Q');
plot(q,meanz,'-s','MarkerSize',5,'MarkerEdg
eColor','red','MarkerFaceColor',[1 .6 .6]);
hold off;
axis([xaxmin xaxmax yaxmin yaxmax]);
text(q,meanz,num2str(meanz'),'vert','bottom
','horiz','center');
ylabel('Priemerný zisk');
xlabel('Q');
plot(q,meanz,'color','#0072BD');
hold on;
stem(q,meanz,'.','color','#0072BD');
axis([xaxmin xaxmax yaxmin yaxmax]);
text(q,meanz,num2str(meanz'),'vert','bottom
','horiz','center');
hold off;
ylabel('Priemerný zisk');
xlabel('Q');
bar(q,meanz);
text(q,meanz,num2str(meanz'),'vert','bottom
','horiz','center');
box off;
ylabel('Priemerný zisk');
xlabel('Q');

toc;
```

Four graphs were created within the graphical outputs to illustrate the possibilities of graphical outputs from the Matlab program.

There are 4 variable declarations at the beginning of the code. These were created to modify the boundaries of the x and y axes in the graphs. This step is not necessary, the program would draw graphs without it. By default, however, the graphs starts at 0.0, the maximum of the y-axis is the maximum value of y and the maximum of x is the maximum of x, so the points are drawn at the graph boundaries, which is disturbing, especially if we want to add a description or highlight them. Therefore, we have declared 4 points that determine the minimum and maximum on the x and y axes. Their name is an abbreviation of their purpose, e.g. xaxmin is the x axis minimum, or the minimum on the x axis. Their values are calculated based on a given value, e.g. the maximum on the x-axis, plus 5% of its length. The others are calculated similarly, but with other coefficients, which we determined by observing the graph.

Declaring the borders is followed by the creation of the first graph. The command to create a line chart is plot. This is a very simple command in which only the first two parameters, x and y values, are required. Other parameters are set by default. So, at the beginning we have x and y axes. We set the first parameter of the x-axis to the variable q and the second parameter of the y-axis draws data from the meanz variable. Subsequently, the '-s' statement defines the line type and point markings on the graph. The line will be solid '-' and the points on the graph will be marked with a square 's' (square). Next we defined other parameters of the graph. There are no rules of order when defining them. Thus, any parameter can be defined anywhere within the bracket of the plot command. Therefore, it is always necessary to first define the parameter that can be set by its name. The parameter name is followed by the parameter value. The first parameter that was defined was the size of the point mark on the graph using the 'MarkerSize' keyword. We set the value to 5 units. 1 unit = 1/72 inch. Next, we set the border color of the point marker to red using the 'MarkerEdgeCo-lor keyword and the' red 'value. The color was set directly by its name, which is defined in Matlab. Next, we set the color of the interior of the point on the graph to a faint red shade with the keyword 'MarkerFaceCo-lor' and the value [1 .6 .6]. It is an abbreviated color definition notation according to the RGB scheme [1 0.6 0.6]. We deliberately used two different kinds of color definition to show that it is possible to use multiple kinds of definitions. The plot command is followed by a hold command with the off parameter. The hold command determines whether the next chart is rendered, whether to the current chart or to a new chart window. Off means no, so the graph will not be held, and the new graph will be plotted in the new window. These two commands alone are enough to generate graphs. We added to them the modification of the x and y axes borders and their names. The axis command sets the boundaries of the x and y axes. We used the values calculated at the beginning of the section. The following are the ylabel and xlabel commands that add names to the x and y axes. The first graph output is shown in Figure 2.

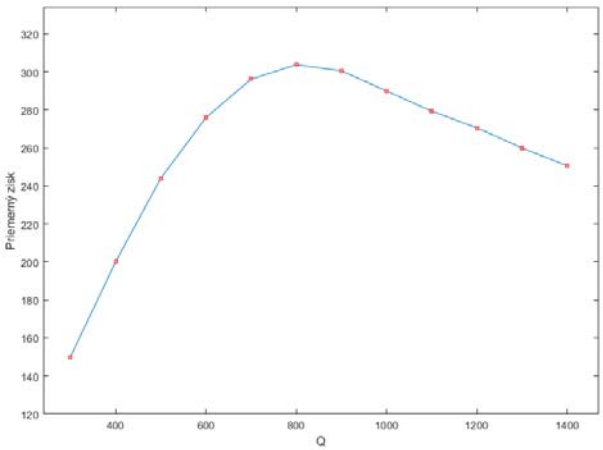

Figure 2. The first graph output.

We defined the second graph as the first, with one difference. We have added names to the chart using the text

function to add descriptions to the chart at the specified points. Similar to plotting a graph, the x and y axes need to be specified in this function to know where to place text markers. We used the variables q and meanz on the x and y axes. Another parameter in the function is the text of the axis description. Here we entered meanz values. However, we had to convert them to a string because number values cannot be output. The num2str function was used for this. In addition, inside the function, the upper quotation mark ‘was used to separate meanz values. Without the quotation mark, the entire meanz field would be displayed at each point. The quotation mark ensures that it displays only the corresponding value, the others are cut off. That would be all the mandatory parameters, but we also set the vertical and horizontal alignment. Vertical alignment with the ‘vert‘ keyword to ‘bot-tom’ or down. Horizontal alignment with the ‘horiz‘ keyword to ‘center‘. The other parameters of the graph are the same as the first. The output of the second graph is shown in Figure 3.

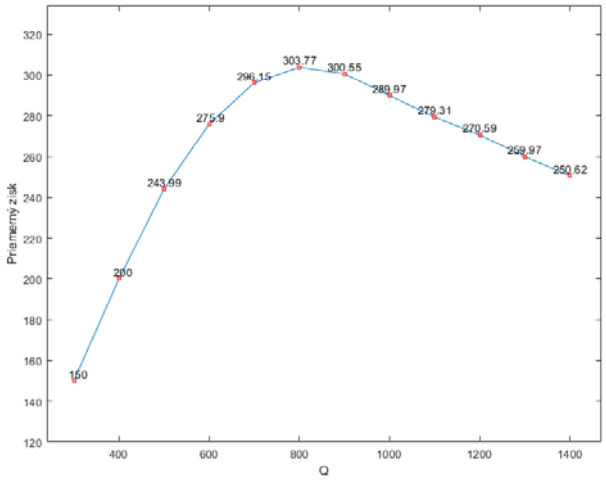

Figure 3. The second graph output.

The third statement again extends the previous statement. First, it contains two hold functions. The first is set to on, the second is set to off. This is because between them there is a plot of the second type of graph - the vertical line graph, that plots into the body of the previous graph. The first hold on function allows us to draw a second graph into the first body. The stem function was used to draw a line graph. Its input parameters are the same as the plot function, except for the output display. Instead of a line graph where the line connects the points formed by the coordinates, it plots vertical lines from the x-axis to the height determined by the y-axis. In the function parameters, we set the line type to dashed by the ‘-‘ statement. We have turned off the point marking with the ‘Marker‘ parameter, which we set to ‘none‘, i.e. no marking. The colour of the chart was set by the ‘color’ parameter, which we assigned a value in the form of the hexadecimal colour code‘ # b3d9ff ‘. We chose this method to illustrate, along with the previous examples, the possibilities of defining colours and to show that there are several right paths to the result. Again, the graph function is followed by definitions of boundaries, text, and description of the graph, and a hold function with the parameter off to prevent another graph from being drawn into the body. Boundaries, texts and graph descriptions are sufficient if two graphs are drawn into one output only once, it is not necessary to do it for each. The output of the third graph is shown in Figure 4.

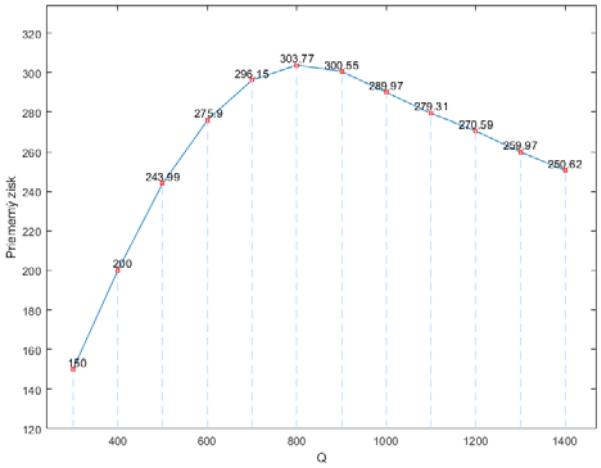

Figure 4. The third graph output.

The last, fourth graph is of the column type. To create it, use the bar function, which again accepts the same parameters as the previous chart types. In this case, we decided to define only the x and y axes with the variables q and menaz. We left the other parameters as default. The following are statements to display descriptions above the graph columns, naming the x and y axes. These commands are the same as in the previous graphs. In addition, there is a function box with parameter off. The default is on, so on. The box creates a bounding line around the graph with a scale from all sides. Since the x and y axes have their own scaling and have a value above each column, we decided to turn this feature off. The output is shown in Figure 5.

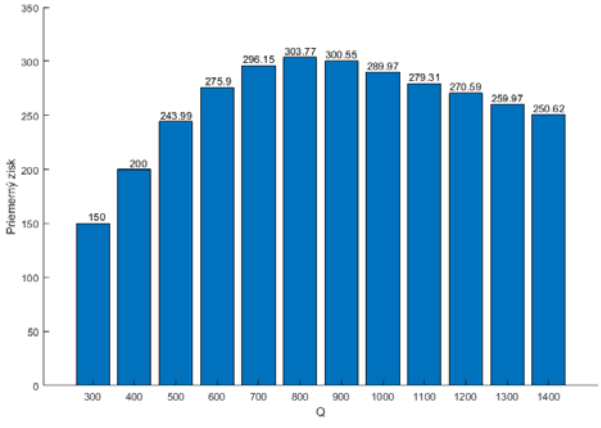

Figure 5. The fourth graph output.

Behind the graph creation code is the toc function described above to record the execution time of the program. This is the end of the algorithm's source code.

DOI: 10.26552/tac.C.2020.1.4

In addition to the listed outputs, a Workspace is also available. Workspace is a space where all variables created during the program are stored. They are available after the execution is complete, or during the execution (unless clear statement is used). All variables can be exported as a table in multiple formats, e.g. .txt, or .xls through the writetable () function. This data can be used for further analysis and to generate additional outputs. The workspace created in our program is shown in Figure 6. It contains an overview of all the variables that have occurred. Variables labelled as a multiplication of two numbers are vectors indicating their dimensions.

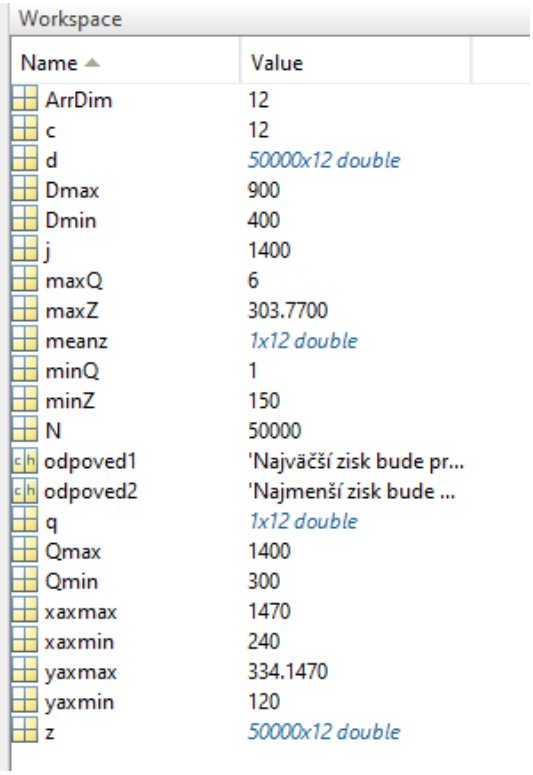

Figure 6. Workspace with variables.

3.4. Simulation results

Through the created simulation model, we can proceed to the solution of the given example. Inputs and input formulas are shown in the described simulation model. We decided to draw the conclusions from the last type of bar graph shown in Figure 5, because it seems to us most readable.

In the simulation, the examined quantity of goods was added. We set it from 300 to 1400 pieces of postcards. We decided for a minimum of 300 because the minimum demand is 400 and we wanted to point out the difference in profit. In the case of 300pcs and 400pcs, there could never have been a discount sale and the products were sold at full margin. Therefore, the difference in profit between the two options is the largest of the two options. Full purchasing power has always been used. At 500 pieces, a slight decrease in the rate of profit growth is evident. For other supply volumes, the rate of increase in profit gradually decreases. The maximum is reached at the level of 800 postcards. This amount achieved an average estimated profit of EUR 303.77. Beyond the supply level of 800, the average profit started to decline. The graph in Figure 5 shows that the rate of descent is less than the rate of climb to the maximum.

By extending the ordered quantity to 2400 pieces and leaving the same amount of attempts to generate pseudo-random numbers 50,000 and other parameters, we get the graph shown in Figure 7.

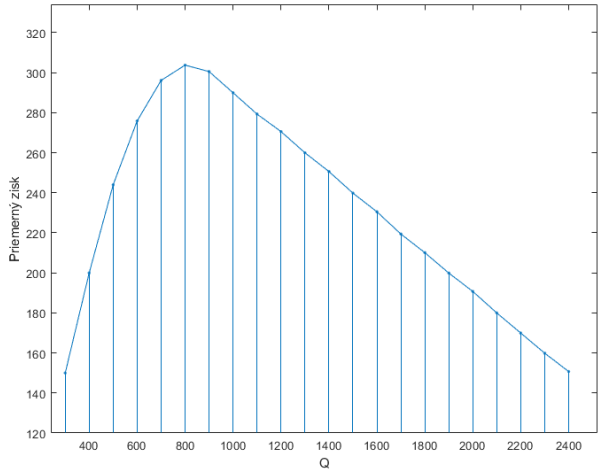

Figure 7. Extended graph

From the graph it can be concluded that values from 300Q to 800Q have a distribution similar to the square root function, while values from 800Q to 2400Q are more like a linear function distribution.

Conclusion

By this research we wanted to show the possibility of using Monte Carlo method to support managerial decision making through simulation model. We created a model that was applied to a simple economic example from the postal environment. The model itself was created in Matlab to show the possibilities of this program. Through the model, the demand of customers was simulated and the optimal amount of products offered was found, with which according to the established formulas the greatest profit will be achieved. Based on the results of the simulation, we found that the biggest profit will be achieved by the company with the offered quantity Q = 800 products in the amount of EUR 303.77.

The created model provides the user with various types of outputs in both text and graphical form. The user also has stored variables to work with and analyse in order to obtain additional outputs. The advantage of the model is its modularity. In the algorithm we used a uniform distribution to generate pseudo-random numbers. This distribution can be replaced by another distribution by modifying a command

in a program that provides the generation of elements into the variable d (i, c).

ACKNOWLEDGEMENTS

This article was published with the support of project EUREKA-E! 11158 U Health Auto-ID technológie a internet vecí na zvýšenie kvality zdravotníckych služieb.

This article was published with the support of project VEGA 1/0721/18 Výskum ekonomických dopadov vizuálneho smogu v doprave s využitím metód neurovedy.

REFERENCES

[1] R. Hušek, J. Lauber. Simulačné modely. Praha: SNTL/ALFA, 1987. 349s. ISBN 978-80-562-0075-9

[2] Achimský, K., Čorejová, T., Fitzová, M. Kajánek, B. Projektovanie sietí v pošte I. Vysoká škola dopravy a spojov v Žiline. Edičné stredisko VŠDS, Žilina. 1995. 147s. ISBN 80-7100-238-0

[3] Všeobecné základy modelovania. [online]. [citivané 25.05.2019]. Dostupné na internete: http://www.fbi.uniza.sk/ktvi/leitner/2_predmety/OA/00_Vseobecne%20o%20modelovani.pdf

[4] Achimský, K. Simulácia s použitím jazyka GSAP II. In: R-687-010 ˇUVT VŠDS. Žilina. 1982. 38s.

[5] Achimská. V. Modelovanie systémov. Žilina: Žilinská univerzita v Žiline, 2011. 96 s. ISBN 978-80-554-0450-9

[6] Úvod do modelovania a simulácie, metóda Monte Carlo. [online]. [citované 25.05.2019]. Dostupné na internete: http://fbi.uniza.sk/ktvi/leitner/2_predmety/SMOA/04_StatistikaExcel/MCprednaska.pdf

[7] What is Matlab? [online]. [citované 26.05.2019]. Dostupné na internete: https://nl.mathworks.com/discovery/what-is-Matlab.html

[8] What Is a Live Script or Function? [online]. [citované 26.05.2019[. Dostupné na internete: https://nl.mathworks.com/help/Matlab/Matlab_prog/what-is-a-live-script-or-function.html

Transport and Communications, 2020; Vol. I.
ISSN: 1339-5130

Socio-Economic Impacts of Road Infrastructure Development During- and Post-Construction in a Fast-Growing City in Nigeria

Nathaniel Oluwaseun Ogunseye[1], Oluwaseun Emmanuel Oyejola[1], Umar Obafemi Salisu[1], Surajudeen Oluseyi Momodu[1], Simeon Oluwagbenga Fasina[1]

[1]Department of Urban and Regional Planning, Olabisi Onabanjo University, Ago-Iwoye, Ogun State, Nigeria

Abstract Road infrastructure is vital to the development of any human settlement and thus it remains an integral part of the municipalities' annual budget. Despite the numerous benefits road infrastructure development (RID) offers, its development imposes negative impacts. While literature is replete with studies on socio-economic impacts of RID at post-construction stage, attention has not been paid to impacts during construction. Consequently, this study aims at analysing the socio-economic impacts of RID during- and post-construction in Abeokuta city in Nigeria. Multistage sampling technique was utilised in sample selection for the study. Both descriptive and inferential statistics were adopted for data analysis with the aid of Statistical Package for Social Sciences (SPSS). Findings from the descriptive analysis indicated that residents were adversely impacted during construction in areas such as business activities, travel rate, property value, vehicle condition and community health. Regression analysis revealed road development statistically impact on socio-economic activities during construction with three out of nine predictors: transport fare (p=0.009), business activities (p=0.015), and community health (0.031) exerting the major influence. Also, at post-construction stage, regression analysis revealed road development statistically impact the socio-economic activities with four of the nine predictors: transport fare (p=0.042), business activities (p=0.009), community health (p=0.035), and property value (p=0.003) exerting the most significant influence. Student t-test results showed that statistical difference existed between 'during construction' and 'post-construction' impacts regarding property value, business activities, community health and transport fare. Finally, the study suggested ways to mitigate problems associated with RID, particularly during construction.

Keywords Abeokuta, construction, Nigeria, road infrastructure development, socio-economic impact

JEL : R49

1. Introduction

Transport is regarded as the "engine of growth and development in any economy" [1]. As a public utility, transport supplies essential goods and services, the absence of which can result in a total or partial collapse of an economy [2].

The importance of transport to any nation can be appreciated if it is considered that it provides for economic, social, political, cultural and technological needs of individual and society [1]. The varied roles stem from the fact that human activities are not concentrated in just a lo cation, and therefore, the need for man to access the diverse
needs, ranging from shelter, recreation, work, social interaction, religious, and to commercial activities [3]. It is on this premise that transport is being described as "lifelines for people and society" [4]. But when road infrastructure is undeveloped in any human settlement, for certain reasons, economic costs are imposed [5]. Similarly, reference [6] posited that the transport development process is not without externalities such as pollution, noise, dirt and congestion, which affect people's health and climate change.

Studies have been conducted focusing on the impact of road infrastructure development globally. Reference [4] studied the socio-economic impacts of road condition on low volume roads in rural areas of the northern periphery of Europe. Johansson was interested in the socio-economic considerations taken by the road management of partner countries (Scotland, Norway, Sweden and Finland) and concluded that the "target standards for the general road conditions and lowest acceptable standards are more or less expressed and socioeconomic models are used for budget discussions and budget distribution." Reference [7] the impact of road construction on the socio-economic condition of the communities in the hilly terrain of Lunglei district, Mi-

zoram, India and results revealed that road construction brought about an improvement in the community livelihood and increase in the number of educational and health centres. Also, there was an increased number of people in certain jobs such as carpentry and handloom, and further, stimulate the efficiency of import and export of goods and services.

Reference [8] posited that the construction of North Coast Highway in Jamaica affects diverse stakeholders. Study results indicate that almost 50% of the respondents have positive perceptions of the North Coast Highway. Most of the respondents adduced the positive perception to the ability to travel with ease. Other benefits identified by respondents include a reduction in flooding due to construction of proper drainage system; less wear and tear on motor vehicles; improved safety and driving conditions; and more trading opportunities as there are inflows of more persons (traders who sell from outside). Conversely, most respondents complained of spending less time with their family, which they attributed to traffic congestion in the North Coast Highway. In another study by Reference [5], the socio-economic impact of road development in Ethiopia with a focus on three roads comprising Gendewuha-Gelago, Mile-Weldiya and Gindi-Kachisi were conducted. Findings show that positive impacts are more than negative impacts across the three corridors despite differences among the different locations. Also, the result indicated that paved highway generates more positive impacts compared to gravel roads. Again, it is noteworthy that Bogale's study focuses on the description of the socio-economic conditions of the residents both before and after the road construction. Reference [9] examined socio-economic benefits and environmental impacts of Thika Road superhighway in Nairobi, Kenya and results revealed that roads development had majorly positive impacts in the areas of investment opportunities and market opportunities whereas the negative impacts are pronounced in the environmental aspects particularly vegetation and wildlife. Reference [10] investigated how highway development and road expansion affect the structure and the general setting of Abeokuta city in Nigeria. Findings indicated that the study area experienced free and smooth traffic flow; increased inflow of residents and businesses into the study area resulting in high demand for housing, and then property value; as well as the opening up of the study area for greater business activities culminating in high cost of rents and leases.

In Nigeria, road transportation is the predominant mode with over 90% of domestic freights and passengers being moved by this mode [1, 11]. This overdependence has been linked to its advantages of accessibility, flexibility and availability [1]. It is also noteworthy that the demand for urban transport has been on the rise due to growing urban population throughout Nigerian cities [12]. However, the road network is being described as poor except for Abuja, which is a new city having modern roads and an extensive network of the pedestrian walkway [12]. While roads in Nigeria are in deplorable condition, the efforts by the government to address the issue are also noteworthy as over 60% of the national investment on transportation has been allocated to road transport infrastructure [1].

Given the above background, it is evident that there is a correlation between the construction of road facilities and the economic development of a city. It is also worth noting that road development impacts could either be direct or indirect. There are also impacts "during construction, those along a newly completed road, and those with long-term impacts" [9]. However, most studies focus on the impacts of the road construction after completion, but there is a dearth of study particularly in developing countries including Nigeria that examined road infrastructure development impacts during construction and post-construction phases. This study aims at analysing the impact of the road construction during- and post-construction stages on the socio-economic development of Abeokuta metropolis. The specific objectives are to examine wide-ranging impacts of road infrastructure development on business (commercial) activities, travel rate, property value, road accident occurrence, transport fare, vehicle condition, community health/wellness, commuting choice and gender travel. It is hoped that the results of the study would help policymakers appreciate the variations between road infrastructure development impacts during- and post-construction stages, and more importantly, inform policy and aid decision-making regarding road infrastructure development for the overall benefits of the populace not only in the study area but across Nigerian cities and other cities embarking on similar projects.

2. Study Area

Abeokuta, the capital of Ogun State of Nigeria, lies between 7º15N and longitude 3º25E. The city is about 81km southwest of Ibadan, the capital of Oyo State and 106km north of Lagos State, the former capital of Nigeria. Its population based on the 2006 National Population Commission census was put at 451, 607 persons. It has been projected to reach 1.2 million by 2025. Abeokuta is the cradle of western education in Nigeria as it embraced first set of missionaries over 170 years ago [13]. Abeokuta city encapsulates Abeokuta North and Abeokuta South local government areas (LGAs) (Figure 1).

DOI: 10.26552/tac.C.2020.1.5

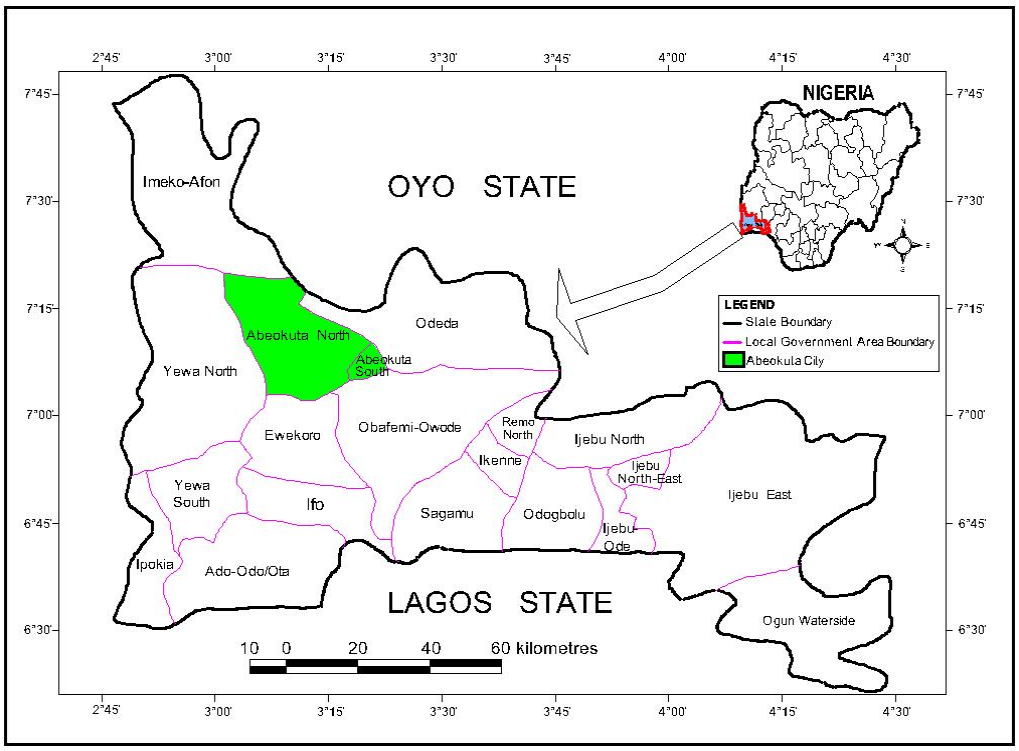

Figure 1. Map of Abeokuta city in Ogun State, Nigeria

3. Materials and Methods

This study utilised questionnaire as data collection instrument. The questionnaire contained a combination of closed and open-ended questions. The questionnaire was divided into three sections. Section A captures the socioeconomic data such as gender, age, marital status, employment status, occupation and education. Section B focuses on impacts during the construction phase and the questions posed addressed impacts on businesses, travel rate, property value, accident rate, transport fare, vehicle condition, community health and commuting choice. Section C deals with impacts in post-construction phase; to which similar questions in the case of during construction were posed. Also, literature review was conducted and it forms the background for this study.

To select samples for the study, a multistage sampling technique was adopted. The first stage involves a stratified sampling technique whereby two LGAs (Abeokuta North and Abeokuta South) that makeup Abeokuta city were selected. At the second stage, the convenience sampling technique was used to select one route each from the selected LGAs. The selected routes are Moore Junction-Adatan Road and Onikolobo-Panseke Road. While Moore Junction-Adatan Road is situated in Abeokuta South local government area (LGA) and is 1.6-kilometre-long, Onikolobo-Panseke Road is in Abeokuta North LGA and is about 800 metres in length. The selected routes were major roads of 12 metres right-of-way and the adjoining developments along them were dominated by mixed-use developments particularly residential and commercial land uses. The last stage was where 30 questionnaires each were administered among the residents along the two selected routes using a random sampling technique. Overall, 60 questionnaires were administered which form the sample size.

The data collected were analysed using both descriptive (frequencies and percentages) and inferential (regression and paired sample Student "t" test) statistics. The analytical tool used was the Statistical Package for Social Sciences (SPSS) version 25.

For this study, three hypotheses were formulated and subjected to test. They are as follows:

i. H_0: Road development does not statistically influence or impact socio-economic activities during the construction period
ii. H_0: Road development does not statistically influence or impact socio-economic activities after the construction period
iii. H_0: There is no statistical difference or variation between socio-economic implications during construction and post-construction periods.

4. Results

4.1 Socio-economic Characteristics of Respondents

The results show that 53.3% of the respondents were males while the remaining (46.7%) constitute the females. Also, the dominant age group was 20-35 years accounting for 48.3%. It was observed that respondents' travel rate decline with the increase in their age. The majority (55.0%) of the respondents were married while 45% were single, thus indicating a potential increase in the population. A larger percentage (75%) of the respondents were employed, and the majority (46.7%) of whom are civil servants. 75% of the respondents obtained formal education whereas 23.3% had informal education, which thus implies that the study area is a literate society.

4.2 Impacts During the Construction Stage

Results from analysis of impact on businesses during construction indicated that 43.4% of the respondents reported late to workplace and 23.3% experienced low business patronage (Table 1). It was inferred that during the construction, businesses suffered some challenges, particularly lateness to workplace and low business patronage.

Of the total respondents, 55.0% said their travel rate was negatively affected during construction while 45.0% thought otherwise. The reasons adduced for the reduced travel rates were traffic congestion (31.6%), air pollution (dust) (28.3%), plying longer routes (15%), bad roads (13.3%), and a late notice of road diversion (Table 1).

During construction, the majority (46.7%) of the respondents opined that there was no impact on property value whereas 41.7% believed it has an impact. The impacts imposed were in form of building loss (40%) and loss of land (25.0%) (Tables 1). Loss of buildings implies that property owners have to be compensated. But this is dependent on whether the property owners possess the certificate of occupancy (a legal document), recognised by the Nigeria's Land Use Act of 1978. In this case, the State government takes responsibility for the payment of compensation to the affected property owners. For those who experienced the loss of land, they lacked spaces to perform some functions within their allotments. Though for parking-related function, they resort to on-street parking.

Road accident occurrence during construction is marginal as affirmed by 26.7% of the respondents. The road accident occurrences were linked to lack of traffic direction (23.3%), over speeding (18.3%) and poor road condition (16.7%) (Table 1).

38.3% of the respondents opined that during road construction there was an increase in transport fare while 13.3% claimed a reduction. The remaining 30.0% stated no variations (Table 1). The results suggest inconsistencies in transport fare charges caused by lack of regulation of the commercial transport operators' activities.

Again, 36.7% of the respondents stated that during road construction their vehicles were prone to series of mechanical faults, 29.3% complained of damages to tyres, and 11.7% identified impacts such as damaged shock absorber and wheel alignment problems (Table 1). With the majority (68.4%) having issues with their vehicles, it can be deduced that vehicles condition deteriorate faster during the construction stage.

In Table 1, the results on impact on commuting choice during construction indicated that 53.3% of the respondents preferred public transport over private transport (41.7%). The choice of commuters may have been influenced by the damages caused to their private vehicles. It is noteworthy that, with the considerable percentage still preferring private transport indicate that there are respondents who could not compromise privacy and convenience that private transport offered compared to public transport.

Analysis of impact on community health during construction stage shows that 66.7% of the respondents were affected by air pollution (dust), equal proportion (13.3%) experienced catarrh and body pain, and 1.7% complained of headache, fever, nausea, and itching eyes (Table 1).

DOI: 10.26552/tac.C.2020.1.5

Table 1. Impact During Construction

		Frequency	Percent
Impact on businesses	Low patronage	14	23.3
	Increase patronage	9	15.0
	Easy access to work	3	5.0
	Lateness to work place	26	43.4
	No response	8	13.3
	Total	*60*	*100.0*
Impact on travel rate	Yes	33	55.0
	No	27	45.0
	Total	*60*	*100.0*
Reasons for travel rate	Bad roads	8	13.3
	Air pollution	17	28.3
	Traffic congestion	19	31.7
	Late notice of road diversion	4	6.7
	Plying longer routes	9	15.0
	No response	3	5.0
	Total	*60*	*100.0*
Impact on property value	Yes	24	40.0
	No	28	46.7
	No response	8	13.3
	Total	*60*	*100.0*
Category of impact on property value	Loss of building	24	40.0
	Loss of land	15	25.0
	No response	21	35.0
	Total	*60*	*100.0*
Impact on road accident	Yes	16	26.7
	No	39	65.0
	No response	5	8.3
	Total	*60*	*100.0*
Causes of road accident	Poor road condition	10	16.7
	Lack of traffic direction	14	23.3
	Over speeding	11	18.3
	Others	1	1.7
	No response	24	40.0
	Total	*60*	*100.0*
Impact on transport fare	Increase	23	38.4
	Reduction	8	13.3
	No changes	18	30.0
	No response	11	18.3
	Total	*60*	*100.0*
Impact on vehicle condition	Prone to mechanical faults	22	36.7
	Bad tyres and wheels	12	20.0
	Shock absorber & wheel alignment problems	7	11.7
	No response	19	31.7
	Total	*60*	*100.0*
Impact on commuting choice	Public transportation	32	53.3
	Private transportation	25	41.7
	No response	3	5.0
	Total	*60*	*100.0*
Impact on community health	Dust (air pollution)	40	66.7
	Catarrh	8	13.3
	Body pain	8	13.3
	Others	1	1.7
	No response	3	5
	Total	*60*	*100.0*

4.3 Post-Construction Impacts

The results from Table 2 regarding impacts on businesses after construction revealed that 21.7% of the respondents experienced an increase in patronage, 38.3% opined that new road provides easy access to work and business locations, and 18.3% stated low patronage. It can be implied from the results that the new roads have positive effects on business due to smooth surfaces, and the free flow of traffic.

The newly constructed road increased the travel rate as the respondents are willing to commute to and fro within the study area. This assertion was supported by the results indicating that the majority (58.3%) of the respondents were encouraged to travel frequently**.** The reasons for the increase in travel rates were mainly easy traffic flow (61.7%), easy accessibility (25.0%), and reduced risk of accident (13.3%) (Table 2). Smooth tarred surfaces and wide roads encourage more travels, allay fear of traffic congestion due to poor and narrow roads, or incidences of the faulty vehicle.

Regarding property value, the results revealed almost half (48.2%) of the respondents agreed to the value-added impact of road construction and 51.8% did not agree. The actual impacts on property value were in form of increased property rentals (30%), property accessible by road (11.7%), aesthetic (1.7%), and 15% constitute those with multiple impacts like aesthetic and improve accessibility or even aesthetic and increased property value (Table 2).

The post-construction impact on accident rate revealed that 63.3% of the respondents disagreed that newly constructed road caused accidents whereas 30% agreed it contributed to the accident rate. The reasons for accident occurrence are over speeding (43.3%), lack of road furniture (6.7%), and good road condition (1.7%) (Table 2).

The results on post-construction effect on transport fare showed the transport fare increase despite the good road condition. The increment in fare may be due to other factors like immigration to the study area, being the capital city, which most times is characterised by high living standards as witnessed in Nigerian capital cities. An earlier study by [10] confirmed inflow of residents into Abeokuta as a result of highway development and expansion.

The post-construction impact on vehicle condition reveals that 20.0% of the respondents perceive an improvement in vehicle condition, 23.3% stated that tyres last longer when compared to the construction stage, and 21.7% said there were fewer issues of repair of shock absorber, wheel alignment and balancing (Table 2). The results imply that vehicle owners would have their expenses on servicing and repairs reduced as compared to during construction.

The result of the post-construction impact on commuting choice showed that over half (53.3%) of the respondents preferred to travel by public transportation, 31.7% chose private transportation and 15.0% were undecided on their preferences as a result of the impact.

The improvement in community health at post-construction phase can be linked-to the absence of the externalities imposed by construction processes. Results showed that 43.3% of the respondents had easy access to the other services within the community, 36.7% commute without stress and 10% confirmed they spent less time on the road.

Table 2. Post-Construction Impact

		Frequency	Percent
Impact on businesses	Low patronage	11	18.3
	Increase in patronage	13	21.7
	Easy access to work	23	38.3
	Others	6	10.0
	No response	7	11.7
	Total	*60*	*100.0*
Impact on travel rate	Yes	35	58.3
	No	25	41.7
	Total	*60*	*100.0*
Determinants of travel rate	Easy accessibility	15	25.0
	Free flow of traffic	37	61.7
	Reduced risk of accident	8	13.3
	Total	*60*	*100.0*
Impact on property value	Yes	27	45.0
	No	29	48.3
	No response	4	6.7
	Total	*60*	*100.0*
Category of impact on property value	Aesthetic outlook	1	1.6
	Nearness to road	7	11.7
	Increase property rentals	18	30.0
	Others	9	15.0
	No response	25	41.7
	Total	*60*	*100.0*
Impact on road accident occurrence	Yes	18	30.0
	No	38	63.3
	No response	4	6.7
	Total	*60*	*100.0*
Causes of road accident	Good road condition	1	1.7
	Lack of road furniture	4	6.7
	Over speeding	26	43.3
	No response	29	48.3
	Total	*60*	*100.0*
Impact on transport fare	Reduction	5	8.3
	Increase	29	48.3
	No changes	26	43.3
	Total	*60*	*100.0*
Impact on vehicle condition	Improved vehicle health	12	20.0
	Long lasting tyres	14	23.3
	Others	13	21.7
	No response	21	35.0
	Total	*60*	*100.0*
Impact on commuting choice	Public transportation	32	53.3
	Private transportation	19	31.7
	No response	9	15.0
	Total	*60*	*100.0*
Impact on community health	Easy accessibility	26	43.3
	Stress free	*22*	*36.7*
	Time saving	*6*	*10*
	Others	*1*	*1.7*
	No response	*5*	*8.3*
	Total	*60*	*100.0*

DOI: 10.26552/tac.C.2020.1.5

4.4 Hypotheses Testing

4.4.1 Hypothesis I

H_0: Road development does not statistically influence or impact socio-economic activities during the construction period

Further investigations were conducted to establishing the degree of affinity and percentage of causality between the road development (dependent variable) and socio-economic implications (independent variables) during the construction period in Abeokuta, Nigeria using regression analysis. The model specification for the degree of affinity between the dependent variable and independent variables takes the general regression equation model.

$$Y=a+b_1X_1+b_2X_2+\ldots\ldots b_nX_n+e$$

The results of the regression analysis are presented in Table 3. The regression results show that there is a statistically significant relationship between the road development and socio-economic implications during the construction period in Abeokuta. This result was confirmed through the F-ratio value (2.548) and the observed significant value (p=0.017) in the summary of ANOVA in the regression table. While comparing the observed significant value with the table value, it is clear that the observed significant value (p=0.017) is less than the table significant value (0.05). Hence we accept the alternative hypothesis (H_1) and reject the null hypothesis (H_0). This implies that road development statistically influences or impacts the socio-economic activities during the construction period in the study area. Furthermore, the coefficient of determination R^2 has a value of 31% meaning that the combined influence of the nine (9) independent variables is over 30% on the dependent variable (road development) as an explained variation. The observed low percentage of the coefficient of determination was as a result of the nature of data used for the analysis (qualitatively obtained data and quantitatively transformed data). In other words, the unexplained variation might be due to other factors that were not captured as well as the nature of data used.

Meanwhile, three (3) out of the nine (9) predictors: transport fare (p=0.009), business/trade activities (p=0.015), and community health/wellness (p=0.031) have a positive relationship with road development, that is, they exert the most significant factors that influenced or impacted by road development during construction period, while other factors have no negative relationship with road development during construction in the study area.

4.4.2 Hypothesis II

H_0: Road development does not statistically influence or impact socio-economic activities after the construction period

Also, an investigation was conducted to establishing the degree of affinity and percentage of causality between the road development (dependent variable) and socio-economic implications (independent variables) after construction period in Abeokuta, Nigeria using regression analysis. The results of the regression analysis are presented in Table 4. The regression results show that there is a statistically significant relationship between the road development and socio-economic implications after the construction period in the study area. This result was confirmed through the F-ratio value (2.395) and the observed significant value (p=0.024) in the summary of ANOVA in the regression table. While comparing the observed significant value with the table value, it is clear that the observed significant value (p=0.024) is less than the table significant value (0.05). Hence we accept the alternative hypothesis (H_1) and reject the null hypothesis (H_0). This implies that road development statistically influences or impacts the socio-economic activities after the construction period in the study area.

Furthermore, the coefficient of determination R^2 has a value of 30% meaning that the combined influence of the nine (9) independent variables is over 30% on the dependent variable (road development) as an explained variation. The observed low percentage of the coefficient of determination was as a result of the nature of data used for the analysis (qualitatively obtained data and quantitatively transformed data). In other words, the unexplained variation might be due to other factors that were not captured as well as the nature of data used.

However, four (4) out of the nine (9) predictors: transport fare (p=0.042), business/trade activities (p=0.009), community health/wellness (p=0.035) and property value (p=0.003) have a positive relationship with road development, that is, exert the most significant factors influenced or impacted by road development after the construction period, while other factors have no negative relationship with road development after construction in the study area.

Table 3. Multiple Regression Results Showing Road Development Impacts on Socio-Economic Activities During Construction Period

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.561[a]	.314	.191	.447

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.585	9	.509	2.548	.017[b]
	Residual	9.998	50	.200		
	Total	14.583	59			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.203	.500		2.405	.020
	Transport fare	.233	.086	.420	2.718	.009
	Property Value	-.210	.155	-.212	-1.360	.180
	Vehicle condition	.010	.146	.008	.067	.947
	Business/trade activities	-.144	.057	-.326	-2.529	.015
	Gender travel	.128	.132	.129	.971	.336
	Road accident occurrence	.125	.131	.121	.954	.344
	Community health/wellness	-.154	.069	-.279	-2.223	.031
	Travel rate	.187	.151	.152	1.236	.222
	Commuting choice	-.001	.048	-.003	-.026	.980

a. Dependent Variable: Nature of road development

Table 4. Multiple Regression Results Showing Road Development Impacts on Socio-Economic Activities After Construction Period

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.549[a]	.301	.176	.451

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	4.394	9	.488	2.395	.024[b]
	Residual	10.190	50	.204		
	Total	14.583	59			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.274	.458		2.778	.008
	Road accident occurrence	-.047	.085	-.070	-.556	.580
	Travel rate	-.090	.070	-.178	-1.295	.201
	Vehicle condition	.126	.123	.128	1.024	.311
	Commuting choice	.081	.136	.079	.592	.556
	Gender travel	.035	.148	.033	.236	.814
	Transport fare	-.177	.093	-.241	-1.910	.042
	Community health/wellness	.169	.078	.275	2.164	.035
	Property Value	.239	.078	.411	3.070	.003
	Business/trade activities	-.158	.058	-.357	-2.734	.009

DOI: 10.26552/tac.C.2020.1.5

4.4.3 Hypothesis III

H_0: There is no statistical difference or variation between socio-economic implications during construction and post-construction periods.

Results of the paired sample Student 't' test between the socio-economic implications during construction and post-construction periods are presented in Table 5. The summary of the paired sample test shows that four (4) out of the nine (9) analysed factors of the socio-economic implications shows a statistical variation between the two periods, while the remaining five (5) analysed factors exert no statistical variation. Table 6 revealed that there is a statistical difference or variation between impact on property value (t=4.810, p=0.000), impact on business/trade activities (t=3.034, p=0.004), impact on community health/wellness (t=4.786, p=0.000), and impact on transport fare (t= 4.112, p=0.000). Hence, we accept the alternative hypothesis (H_1) and reject null hypothesis (H_0) for the above analysed socio-economic factors. This implies that the impact of road development on property value, business/trade activities, community health/wellness, as well as transport fare during construction and post-construction varies or differs.

Table 6 also show that there exist no difference or variation between impact on vehicle condition (t= 0.103, p=0.918), impact of gender travel (t=1.625, p=0.109), impact on travel rate (t = 0.468, p=0.641), impact on commuting choice (t= 0.423, p=0.673) and impact on road accident occurrence (t=0.184, p=0.854). Hence, we accept the null hypothesis (H_0) and reject the alternative hypothesis (H_1) for the above-analysed factors. This implies that the impact of road development on vehicle condition, gender travel, travel rate, commuting choice and road accident occurrence during construction and post-construction periods does not vary or differs.

Table 5. Student t-test Results Between Socio-economic Implications during Construction and Post-Construction

Paired Samples Test

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Property value (during)- Property value (post)	-.617	.993	.128	-.873	-.360	-4.810	59	.000
Pair 2	Vehicle condition (during) – Vehicle condition (post)	-.017	1.255	.162	-.341	.308	-.103	59	.918
Pair 3	Gender travel (during) – Gender travel (post)	.100	.477	.062	-.023	.223	1.625	59	.109
Pair 4	Business/ trade activities (during)- Business/ trade activities (post)	-.600	1.532	.198	-.996	-.204	-3.034	59	.004
Pair 5	Community health/ wellness (during)- community health/ wellness (post)	-.583	.944	.122	-.827	-.339	-4.786	59	.000
Pair 6	Transport fare (during) – Transport fare (post)	.350	.659	.085	.180	.520	4.112	59	.000
Pair 7	Travel rate (during) – Travel rate (post)	-.033	.551	.071	-.176	.109	-.468	59	.641
Pair 8	Commuting choice (during) – Commuting choice (post)	.033	.610	.079	-.124	.191	.423	59	.673
Pair 9	Road accident occurrence (during)- Road accident occurrence (post)	-.033	1.402	.181	-.395	.329	-.184	59	.854

5. Discussions and Conclusions

From the business perspective, the patronage increases during the post-construction phase in comparison to during construction. Residents confirmed greater access to the workplace at post-construction, a factor which was a concern during the construction phase. The increased patronage indicates an improvement in the residents' livelihood and economic prospects for residents as they are guaranteed patrons not only within their neighbourhood but outside. This result corroborates findings of studies by [7, 8, 9].

Residents' travel rate improved at the post-construction stage. The result supports the findings of [8, 10]. The improvement recorded is mainly due to free traffic flow made possible by smooth paved surfaces and improved right-of-way. This new road attributes eliminate problems of traffic congestion, poor road condition, plying the longer alternative route and a late notice of road diversion to the motorists by the construction firm.

The property value appreciated at post-construction phase compared to during construction. Unlike during the construction phase when residents experienced impacts in form of loss of buildings and land area (reduction in available space), residents confirmed an increase in rentals, property proximity to roads and aesthetic outlook contributed to the property value. Reference [10] study affirmed that respondents agreed to road expansion effect on rents and leases.

Public transport fare increment was experienced during construction and post-construction stages, which suggest road construction have little or no impact on the transport fare charged by the motorists. The increment witnessed in the two stages regarding transport fare can be linked to unregulated fare operational in Abeokuta city. Consequently, the amount paid to motorists seem to depend on the bargaining power of the commuters.

The poor vehicle condition is a major problem during the construction stage as vehicles are highly prone to mechanical faults, tyres' wear and tear, and shock absorber and wheel alignment problems. But the post-construction impact indicated an improved vehicle condition with a report that tyres last longer and fewer repairs of the shock absorber and wheel alignment. The result agrees with findings of [10] where respondents reported less wear and tear due to construction of North Coast Highway in Jamaica.

The results obtained during construction and post-construction imply that road accidents occurrence are not greatly dependent on the two construction phases examined in this study. However, road accident occurrences during the construction stage were connected to lack of traffic direction, over speeding and poor road condition. Similarly, over speeding contributed to road accident occurrence after construction. It is important to state that problems of over speeding should be addressed, which can be taken as behavioural and psychological issues.

The regression analyses conducted revealed road development exert significant influence on the socio-economic activities during construction and post-construction stages. During construction, the predictors such as transport fare, business activities and community health exert major influence whereas the predictors with significant influence for post-construction are transport fare, business activities, community health and property value. Also, the Student t-test results established that statistical difference exists between impacts during construction and post-construction stages. The variations in impacts are reflected in the variables of property value, businesses, community health and transport fare. In other words, the impacts of road development during construction and post-construction periods do not vary or differ regarding variables of vehicle condition, gender travel, travel rate, commuting choice and road accident occurrence.

Based on the findings emanating from this study, the following recommendations are put forward. First, the government and construction firms should pre-empt possible externalities and put in place measures that would help mitigate the impacts during road construction on residents. Second, the government should see to the release of funding as well as mandate the construction firms to work within the project schedule so that residents would need not bear unnecessary costs beyond the agreed project life. This is important because it has been observed that sometimes construction firms suspend work when required finances are not mobilised at the appropriate time. Third, public sensitisation before the commencement of the road project and continual update on progress made would give a sense of belonging to the populace and prepare their mind for possible self-initiative to cushion the negative impacts that may emanate from the proposed project. Fourth, early notice regarding traffic diversion is desirable during road development, and lastly, efforts towards adopting best practices in the development of road infrastructure in order to maximize benefits and minimise the externalities are highly recommended.

REFERENCES

[1] Badejo, B.A., "Transportation: Removing the clogs to Nigeria's development", Anchorage Press & Publishers, Lagos, 2011.

[2] Bos, D., "Regulation: Theory and concepts", In D. Parker & Saal, D. (Eds), International Handbook in Privatisation, pp. 447-497, Edward Edgar Publishing Model, Cheltenhan, 2003.

[3] Morenikeji, W. "Land use planning and transport system in cities", In K. M. Yari, Ndirmbula, A. G., Nwosu, E. C. G. & Badejo, B. A. (Eds), Transportation challenges in Nigerian cities: A synopsis, pp. 15-36, Nigerian Institute of Town Planners & Town Planners Registration Council of Nigeria, Abuja, 2017.

[4] Johansson, S., "Socio-economic impacts of road condition on low volume roads", Roadex II Northern Periphery, Report being part-financed by the European Regional Development Fund, 2004.

DOI: 10.26552/tac.C.2020.1.5

[5] Bogale, B.D., "Socioeconomic impacts of road development in Ethiopia: case studies of Gendewuha- Gelago, Mile–Weldiya and Ginchi-Kachisi Roads", (Doctoral Thesis), Department of Geography, University of South Africa, 2016.

[6] Oyesiku, O.O., "From Womb to Tomb", 24th Inaugural Lecture at Olabisi Onabanjo University on 27 August 2002. Olabisi Onabanjo University Press, Ago-Iwoye, 2002.

[7] Lalnundanga, Sailo, L., Vanlalbela, C., Malsawmkima, B., "Impact of road construction on the socio-economic condition of the communities in the hilly terrain of Lunglei district, Mizoram, India", Science Vision, vol. 15, no. 3, pp.152-158, 2015.

[8] McGrowder, D., Jackson, L.A., Forrester, R., Edie, C., Crawford, A., Simpson, S., Crawford, T., "The Impact of the North Coast highway on socioeconomic status and family life of residents in Bogue village, Jamaica" Asian Social Science, vol. 5, no. 2, pp.29-37. 2009.

[9] Wanjiku, E.M., "Socio-economic benefits and environmental impacts of Thikaroad superhighway", (Research Project), Kenyatta University, 2014.

[10] Afolabi, O. J., Oyetubo, O. A., Oluwaji, O. A., "Implications of highway development and expansion on urban residents in Nigeria: A case study of Abeokuta metropolis", Nigerian Journal of Technology, vol. 32, no. 2, pp.302-308, 2018.

[11] Badejo, B., "Transportation in Nigerian cities: findings, expectations and future outlook", In K. M. Yari, Ndirmbula, A. G., Nwosu, E. C. G. & Badejo, B. A. (Eds), Transportation challenges in Nigerian cities: A synopsis, pp.123-141, Nigerian Institute of Town Planners & Town Planners Registration Council of Nigeria, Abuja, 2017.

[12] Ogwude, I.C., "Managing transportation infrastructure in Nigerian cities". In K. M. Yari, Ndirmbula, A. G., Nwosu, E. C. G. & Badejo, B. A. (Eds), Transportation challenges in Nigerian cities: A synopsis, pp. 74-98, Nigerian Institute of Town Planners & Town Planners Registration Council of Nigeria, Abuja, 2017.

[13] Ogun State Government, "Ogun State Regional Plan (2005-2025) Final Report", CPMS Limited, Lagos, 2008.

Traffic Congestion and Intelligent Transport System in a Fast-growing Nigeria City

Umar Obafemi Salisu[1], Ayobami Ademola Akanmu[2], Simeon Oluwagbenga Fasina[1], Sekinat Motunrayo Sanni[3]

[1]Department of Urban and Regional Planning, Olabisi Onabanjo University, Ago-Iwoye, Nigeria
[2]Department of Urban and Regional Planning, The Oke-Ogun Polytechnic, Saki, Nigeria
[3]Transport and Logistics Limited, Ibadan, Nigeria

Abstract The dismal performance of the traditional traffic congestion measures and motorist attitudes on Nigeria roads have not only made traffic flow unpredictable and worsening but also worrisome and defiling every measures put-in-place by the Government. To solve these problems, the study assessed traffic congestion and Intelligent Transport System (ITS) in Ibadan, Nigeria. In achieving this, the study examined among others, factors aiding traffic congestion; effectiveness of the existing traffic congestion measures; and the performance and disposition to the use of ITS in the study area. Systematic random sampling was used to administer 386 copies of a questionnaire on commercial motorists, while data collected were analyzed using both descriptive and inferential (Pearson Chi-Square and Fisher's Exact Tests) statistics. Findings revealed that faulty intersections (3.586) and excesses of traffic officers (3.558) were worsening factors aiding traffic congestion in Ibadan city. Meanwhile, electronic traffic signalization (3.558) and law enforcement and regulation (3.499) were rated the most effective existing traffic congestion measures. In other words, real-time traffic signal devices (3.609); automated travel advisory system (3.595) and road congestion pricing devices (3.581) were highly rated and favourably disposed to use ITS. However, the Chi-Square Tests shows that the use Intelligent Transport System is statistically influenced by users' level of education (Sig. value < 0.05). The study concludes that there is a total necessity and willingness to use ITS in the study area. Hence, the study recommends exigent and holistic approach in the provision and enforcement of ITS towards mitigating congestion and other suggestions for improved traffic flow in Nigerian cities including Ibadan.

Keywords Congestion, Cities, Ibadan city**,** Intelligent Transport System ITS, Traffic

JEL R49

1. Introduction

The pivotal roles of transportation in ensuring human survival and achieving sustainable development are enormous. Such roles are even recognized by the targets and components embedded in the recently unveiled Sustainable Development Goals of the United Nations in which Nigeria is among the stakeholders. Similarly, Nigeria cities are not exempted from urbanization, territorial expansion and expanded socio-economic growth which requires an efficient transportation system. In this regard, transport operations have been fostering the required spatial interaction in numerous dimensions in the country [22]. Despite the economic and social impact of transportation in all spheres of national life, its influence in the expansion and concomitant shaping of cities are outstanding and uncompromising as human activities continued to increase and spread across diverse spatial locations where places of works are separated from homes and residences.

Cities have been feeling the adverse consequences of traffic congestion since time immemorial which later become worse during industrial revolution period and aggravated since the 1900s as same forces that draw inhabitants to congregate in large urban areas also lead to intolerable levels of traffic congestion on urban streets. Globally, traffic congestion is rising and indicates a strong global economy battler, while in the same vein reflects the extent at which commuters and drivers waste precious time by sitting in traffic, not to mention the huge environmental impact accrued in the process.

However, traffic congestion, no doubt, is one of the most vexing city problems and cannot be narrowly tackled at the cost of a city's quality of life [29]. It is an indiscriminate global phenomenon that is dramatically impacted by population, economy, infrastructure and the proliferation of rideshare and delivery services. As a result, vehicular traffic congestion is widely viewed as a growing problem in many urban areas because the overall volume of vehicular traffic has continued to grow faster than the overall capacity of the

DOI: 10.26552/tac.C.2020.1.6

transportation system networks [5]. Although, the drastic measure has been put in place by many European counties towards mitigating to the effect of traffic congestion. Significantly, the use of highly functional video surveillance devices and other related intelligent devices have successfully and effectively reduced traffic congestion and incidents along with road networks [27]. Unfortunately, this situation is not so in the Third world countries including Nigeria.

As Nigeria's economy and population continue to grow, the number of vehicles plying the roads and highways continue to increase in volume and intensity, while traffic congestion and complimentary adverse consequences continue to escalate. Also, the counterproductive nature of transportation as denoted by externalities in which traffic congestion is the most nagging issue with far-reaching implications and backwash effects in the society has become a recurring issue [10, 26]. Traffic congestion is a function of the interacting vehicles and is due to poor speed and flow relationships especially when volumes approach capacity at which both the vehicles going slow and vehicles travelling at high speeds contribute and accounted for accumulated traffic consequently causing delay and congestion [11].

The socio-economic consequences of traffic congestion necessitate persuasive reasons in taking actions before related or associated problems become more difficult to manage. Despite government's significant interventions, particularly through human behavioural control, an improvement on the urban road network and capacity expansion in recent times, accessibility and mobility are being increasingly degraded by growing intra-city traffic delay and congestion especially in major Nigerian cities including Ibadan, Lagos, Benin, Osogbo, Akure, Kano, Kaduna, Port Harcourt, Calabar, Onitsha and even Abuja among others. Interestingly, traffic congestion in these cities has continued to attract several attentions from government, researchers, institutions, professional bodies and scholars in the last 42 years. Significantly, scholars such as [1, 2, 4, 6, 18, 23, 24, 25] among others have critically assessed urban transport situation in Nigeria and suggested measures for its curtailment in several national academic discourse and publications.

Accordingly, national attention to ever-increasing traffic congestion in Nigeria reached its foremost peak in 1977 when 'Transportation in Nigeria National Development' formed the theme of the National Conference held at the University of Ibadan, Nigeria. The conference re-vibrated the challenges of transportation in Nigeria cities and called for immediate stakeholders' interventions since then.

Despite these laudable efforts, traffic congestion and traffic flow have not only been worsening in Nigeria urban centres and large cities at an alarming rate but also defiling every measure put in place. For instance, the traditional traffic control measures, as well as the introduction of improved congestion control measures like road capacity expansion, construction of overpass and underpass, ring road and traffic signals in addition to the established institutional human frameworks for manual control through the statutory agencies, have not achieved desired results of ensuring a free flow of traffic. This situation appeared to have reached elastic limits considering the worsening situation of efforts in place to redress the dilemma. Precisely, the extent of the persistent traffic congestion in Ibadan city and many other Nigeria cities is now undermining the importance of transportation to residents, communal wealth and national growth in numerous dimensions. Surprisingly, individuals, businesses and even sectors of the society are being adversely affected by this recurring urban mobility dilemma in the city. Therefore, the acute limitation and dismal performance of the existing traffic control measures in arresting the ever-growing traffic congestion in Ibadan and other Nigeria cities underscore the rationale for devising and exploring other alternatives; hence, the need to shift attention to smart transport technologies vis-à-vis Intelligent Transport System ITS and Information and Communication Technology (ICT) tools to ensure efficient traffic flow and service delivery in Nigeria cities.

It is based on these backdrops that this study assessed traffic congestion and intelligent transport system in a fast-growing Nigeria city of Ibadan city since her transport issues are more peculiar and complex than other fast-growing cities in Nigeria and again, the transport network of the city is without functional and degraded intelligent transport devices. To this end, this study explores and established the opportunities derivable in the use of improved ITS and other smart transport initiatives for efficient and sustainable road traffic operations and management in the fast-growing Nigerian cities and equally bridge the academic gap on the topical issue in the sub-Sahara African countries by proffering better measures and policy recommendations that will facilitate timely, safe and smart mobility delivery in Ibadan city and cities with similar transport characteristics and challenges.

In achieving this aim, specific objectives examined were the motorist profile and route characterization in Ibadan city; factors aiding traffic congestion in the study area; effectiveness of the traditional and existing traffic congestion measures in Ibadan city; the performance and disposition of respondents to Intelligent Transport System ITS and Smart Transport Initiatives STI for traffic congestion and flow management in the study area. In other words, this study was structured into five sections for clear and logical understanding. Following the introductory sections were the conceptual clarification and brief literature review. The third section dealt with the research methodology that gave insight into the study area, sampling procedure, method of data collection and techniques of analysis. The last two sections that are section four and five presented the results and discussion of findings as well as the study conclusion and recommendations.

2. Conceptual Underpinning and Brief Literature Review

2.1. Concept of Smart Transport Initiatives STI

This study is anchored on the concept of Smart Transport which according to [16] encompasses a range of systems and applications to tackle transportation challenges. The concept is otherwise known as Intelligent Transport System (ITS) which include different modes of transport and traffic management, real-time traveller information, centralized fleet management, road usage charging, smart charging for electric vehicles and vehicle-to-vehicle systems etc. smart transport is based on Information and Communication Technology (ICT) which enables the elements within the transport system to become intelligent by embedding sensors and microchips in these elements. These wireless technologies allow communication between these elements to enhance the performance of the system, reduce congestion and increase road safety. Reference [11] sees Information and Communication Technology ICT as a set of heterogeneous technologies (hardware and software) that allow for electronic communication, data collection and processing in distributed networks as well as electronic guidance and management through sensor technologies. As a result, ITS is a system of layers comprising infrastructures, services on these infrastructures, vehicles moving through the system of infrastructures, and persons and freight moving in these vehicles.

Reference [28] were of the view that ITS covers both Information Technology (IT) and Telecommunications that is useful as traffic management solutions for social innovation; hence, ITS/ICT satisfies requirements such as optimization of investment and innovation to affect society and its production capacity. Similarly, the [7] opines that ITS as a key enabler to achieve public policy objectives, support the design of urban mobility, congestion minimization and offer tailor-made alternative measures so aside from being adapted to a wide variety of urban mobility situations. Therefore, as the core of urban mobility package, Intelligent Transport System (ITS) provides very concrete solutions for traffic flow and travel operations and management, thereby reducing congestion and its resulting negative externalities.

2.2. Literature Review

Traffic has always been a common phrase used by an individual in expressing the chaotic vehicular movement experienced in their intra-urban movement and refers to pedestrians or vehicular on the road or the state of ongoing change or the passage thereof in the cities [3]. In this regard, cities have been feeling the adverse consequences of traffic and traffic congestion since time immemorial which later become worse during industrial revolution period and aggravated since the 1900s as same forces that draw inhabitants to congregate in large urban areas also lead to intolerable levels of traffic congestion on urban streets. Globally, traffic congestion is rising and indicates a strong global economy, while in contrary reflects the extent at which drivers' waste time by sitting in traffic, not to mention the huge environmental impact accrued in the process. Traffic congestion, no doubt, is one of the most vexing city problems and cannot be narrowly tackled at the cost of a city's quality of life [29]. It is an indiscriminate global phenomenon that is dramatically impacted by population, economy, infrastructure and the proliferation of rideshare and delivery services. As a result, vehicular traffic congestion is widely viewed as a growing problem in many urban areas because the overall volume of vehicular traffic has continued to grow faster than the overall capacity of the transportation system [5].

Congestion is an unavoidable consequence of scarce transport facilities such as road space, parking area, road signals and effective traffic management. As a result, urban congestion mainly concerns two domains of circulation, passengers and freight which share the same infrastructure. By this, the condition of traffic congestion on road networks occurs as a result of excessive use of road infrastructure beyond capacity, and it is characterized by slower speeds, longer trip hours and increased vehicular queuing. In the opinion of [12], traffic congestion disrupts business activities and reduces productivity level despite being a symbol of growth in an economy since economy grows and increase in real income of household usually lead to a surge in vehicle population thereby contributing to traffic congestion, particularly within cities.

In recent years, and especially since the early 1990s, the increase in road traffic and the demand for transport has caused serious traffic congestion, delays, accidents and environmental problems in large cities. Road traffic jams, according to [13] continue to remain a major problem in most cities around the world, especially in developing regions resulting in massive delays, increased fuel wastage and monetary losses. In Nigeria, and most especially in Lagos, the impact of traffic congestion is palpable to anyone witnessing delay on Lagos roadways as an estimated 8 million people travel to work via public transportation each day on the 9,100 roads and expressways available in Lagos [14]. With more than 1 million registered vehicles in 2011, there are potentially more than one million trips made during the peak travel periods of the day; this is much more during seasonal festivities such as Easter and Christmas when there is an influx from other parts of the country.

According to [17], reformation and advancement in Information and Communication Technologies have resulted in wider applications all over the world in this century. Therefore, the integration of Intelligent Transport Systems (ITS) through ICT solutions becomes necessary towards achieving a smooth flow of traffic in cities and other metropolitan areas in the country. Reference [25] observes that the acceptance of ITS will significantly help to manage road networks, coordinate traffic and reduce travel times. ICT is a value enhancement strategy for ensuring free traffic flow towards achieving effective traffic management in contemporary settlements across the world. Reference [27] observed that the use of multi-sensor video surveillance systems and other smart transport devices along with road networks in

DOI: 10.26552/tac.C.2020.1.6

European cities significantly help to reduce the emergency, traffic flow and traffic incidents on the relevant section of the roads and equally assist the work of traffic inspector in violation measures. With this, ITS and ICT traffic management system is critical in managing traffic flow in contemporary African societies; hence, the rationale for this study in embracing the use of ITS as smart transport initiatives towards achieving improved traffic flow, reduced congestion, coordinate travel time and behaviour and improved traffic safety in Ibadan city, Nigeria.

3. Material and Methods

3.1. Scope of the Study

Importantly, on the locational score, the study was limited to Ibadan city since the city is the biggest in sub-Sahara African and characterized with pressing mobility and accessibility dilemma, alarming congestion, unorganized public transport system, inconsistency transport policies and lack of functional smart transport technologies along major road network corridors despite its socio-economic and location advantages ahead of other cities in Nigeria. On the subject scope, the study was limited to the commercial motorists as the only group of respondents and equally a major group of users who regularly uses and assigned to the major routes within the city for daily urban public commuting services in the fast-growing city of Ibadan.

3.2 The Geography of Ibadan City

Ibadan city, according to [20] is recognized as a nodal settlement because of its transportation network advantage facilitated by its aged long political, administrative and commercial functions in addition to her suitably geographical location being enjoyed till date. The principal routes in Ibadan city are Lagos/Ibadan highway to the South, Ibadan/Oyo/Ilorin highway to the North; Ibadan/Ife/Ilesha highway to the East and Ibadan/Ijebu/Abeokuta highway to the West. Several intra-city routes and corridors which transverse Ibadan provide both mobility and accessibility for all land use and residents.

Ibadan city is geographically located in south-western Nigeria and the south-eastern part of 0yo state, approximately on longitude 3^0 55^l East of the Greenwich Meridian and Latitude 7^0 23^l North of the Equator [9]. The approximate land area of Ibadan city (i.e. 11 Local Government Areas-LGAs) is 55km by 70km totalling 3,850 square kilometres or 385,000 hectares, which is about 14.13 % of the total landmass of Oyo State (27, 249 square km). According to [8], Ibadan emerged around 1830 at a time of political turmoil in Yoruba land and first served as a war camp before it grew to a full-fledged town, and later to attain the status of a city-state with the largest population size in Yoruba land in a gasping manner. According to [19], Ibadan had developed over a large area approximated to 103.8 square km in 1970, while in 1982 it was estimated that the city had covered an area of about 130.5 square Km. The landscape of Ibadan is dotted with hills, river valleys and plains with drainage network of rivers and streams. Meanwhile, Ibadan city is inhabited by 3,464,000 in 2019 based on the projected population using the National Population Commission of 2006. Public transport services are provided mainly by the private sector, notably by taxis, buses and motorcycles [26]. These services are, however, supplemented by the state government-owned Pacesetter Transport Service whose vehicles operate more intercity transportation than intra-city services.

3.2 Methods

The research methods in this study includes the research design, sources of data used, methods of data collection, sampling procedure, population and sample size, method of data presentation and analysis as well as the postulated research hypothesis. This study used a mixed methods of cross-sectional research design that combined both qualitative and quantitative approaches in achieving research objectives. The qualitative approach enables researcher in getting in-depth information on the topical issues, while quantitative approach helped in obtaining and analyzing numerical data from the sample. Meanwhile, both primary and secondary sources of data were employed for this study. The primary data was majorly through questionnaire administration and complemented by field observation of traffic situations and traffic control devices identified along screening routes in the study area. This means of data collection provided the first-hand and insight into the research questions and objectives were addressed. Furthermore, the secondary data was through consultation of relevant and related literature on topical issues in a global manner. However, deductions and inferences were objectively and subjectively made based on the two data sources.

The study was limited to only the registered commercial motorists as a major group of users who are assigned and regularly uses major routes within the city for daily urban commuting services. Meanwhile, systematic random sampling was used to administer 386 copies of a questionnaire on the registered commercial motorists along seven randomly screened route corridors in Ibadan city. The route corridors are Iwo road-Challenge road; Bere/Oje road-Iwo road; Bere/Yemetu road-University of Ibadan road; University of Ibadan road-Sango/Dugbe road; Challenge road-Ring Road/Dugbe; Dugbe road-Apata road, and Dugbe road-Eleyele road. The sample size (386) was extracted from the 2019 registered commercial motorist of ten thousand and eight hundred motorists (10,800) sourced from the National Union of Road Transport Workers (NURTW) in the study area using Taro Yamane sample size formula:

$$n=N/1+N*(e)2$$

Where n= the sample size, N= the population size and e= the acceptable sampling error.

However, out of the 386 administered copies of the questionnaire, a total of 353 copies equivalent of 91.5% were retrieved from the field and used for analysis. Meanwhile, data collection were made possible with the support of research assistants and traffic control officers. Furthermore, collected data were analyzed using both descriptive (percentage distribution table and Summation of Mean Weighted Value MWV) and inferential (Pearson Chi-Square Test and Fisher's Exact Test) statistics techniques with the use of Statistical Package for Social Sciences SPSS IBM version 21.

3.3 Research Hypothesis

The postulated hypothesis was tested to establish the influence of respondents' socio-economic status (educational level) on the use Intelligent Transport System ITS devices in the study area. The research hypothesis was tested using both Pearson Chi-Square Test and Fisher's Exact Test and thus, presented in the alternate form as:

H_1: The use ITS devices is a function of users' level of education

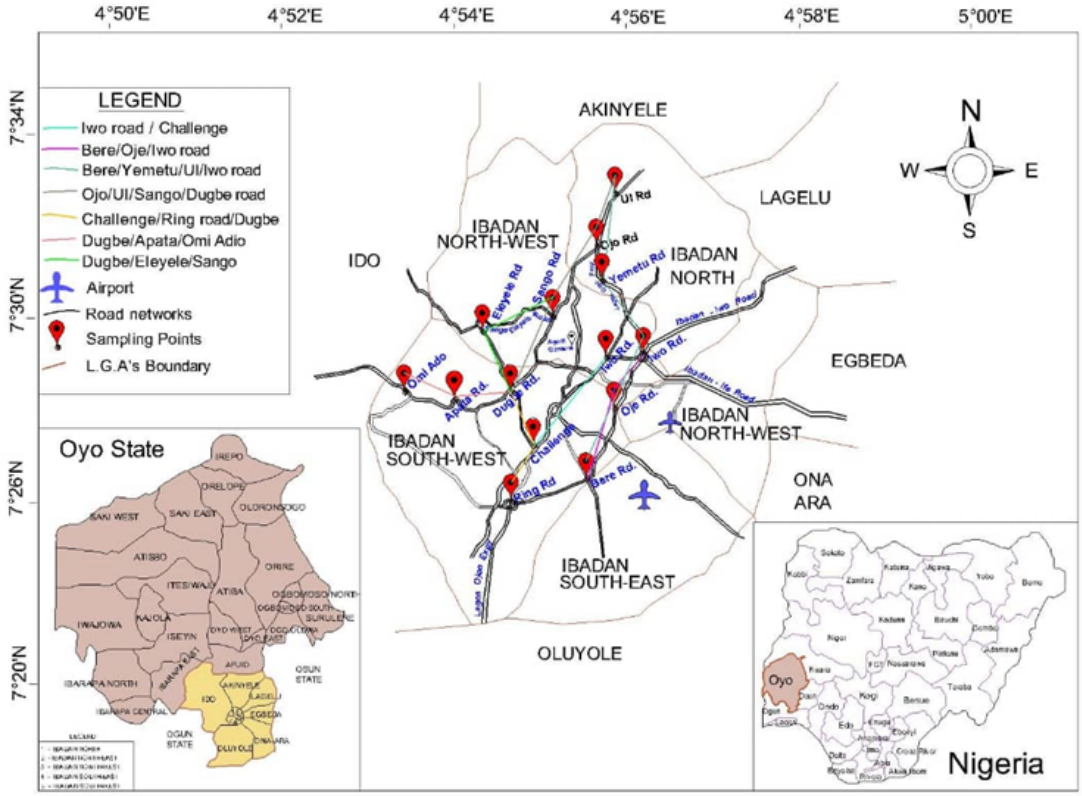

Figure 1. Map of Ibadan city in Oyo State, Nigeria showing the route corridors and sampling points

4. Results and Discussion

The results of the analysis of data obtained from the administered questionnaire are presented in this section. Precisely, it consists of the findings on motorist profile and route characterization, factors aiding traffic congestion in Ibadan metropolis, appropriateness and effectiveness of existing traffic congestion measures, motorists' disposition to smart transport technologies as well as their readiness towards smart transport technology initiatives capable of producing desired results of a free flow of traffic in the study area. The unending traffic congestion in Ibadan is being facilitated by different factors which this study was able to establish and suggested measures towards achieving meaningful reduction if not total eradication.

The analysis was done on a 4-point Likert scale in which the gradation is ranked as VL-Very low; L- low; H- High and VH –Very High in Table 6, while in Table 7, the indices are I: Inappropriate; SI: Slightly Inappropriate, SA: Slightly Appropriate and A: Appropriate. Table 8 has the gradation which consists of SD: Strongly Disagree, D: Disagree; U: undecided; A; Agree and SA: Strongly agree of which the stated graduation was coded as 1, 2, 3, and 4 respectively. The index for each variable is arrived at by dividing the Summation of Mean Weighted Value (MWV) by the total number of responses. According to [10], MWV for a variable is obtained through the addition of the product of the number of responses to each aspect and the respective weight

DOI: 10.26552/tac.C.2020.1.6

value attached to each rating. This is expressed quantitatively as thus:

$$MWV = \sum_{i=1}^{5} X_i Y_i$$

Where:

MWV = Summation of Mean Weighted Value,
Xi = number of respondents to rating i
Yi= the weight assigned a value (i = 1, 2, 3, 4, 5)

With this, the higher the Relative Index Mean Value (RIM), the higher the level of effectiveness for the variable under consideration is and this is expressed quantitatively:

$$RIM = \frac{MWV}{\sum_{i=1}^{5} X_i}$$

4.1 Motorist Profile and Route Characterization

The presentation of findings in Table 1 was done using the simple percentage of the distribution. It is interesting to note that out of the 353 sampled motorists, 94.7% are male while 5.3% are female, implying that majority of the commercial motorist in the study area are male with a huge percentage as compared to their female counterpart. On the age group of respondents, findings revealed that majority (42.7%) of respondents are between age 25- 35 years, 18% is less than 25years of age, 26% are 36-45 years, while the least percentage (13.3%) are respondents above 45 years. This shows that most of the drivers are in their active age with the strength required to meet up the physically demanding jobs available as a source of income or form of employment. Also, the majority (about 70%) of the sampled motorists are married and are expected to display a high sense of responsibility.

Evidence from Table 1 also shows that the majority (about 60%) of motorists' are holders of primary/secondary school certificate holders, while National Diploma holders or its equivalent, Degree certificate holders, and respondents with no formal education accounted for 12.7%, 24% and 6.6% respectively. Concerning the average daily income of motorists, only 5.8% earns below #2,000, while 12.6% earns between #2,000 and #4,000. Also, more than a quarter (39.9%) earns between #4,000 and #6,000, while the remaining 41.7% earns more than #6,000 Nigerian Naira after the deduction of daily running cost. Accordingly, the average daily income of motorists are not the same but vary on the extent and patronage recorded as well as other factors including vehicle ownership, excesses of trade unions and traffic officers.

In other words, the ownership of vehicles being used for commercial transportation operations in the study area varies. Accordingly, Table 1 also showed that 27.2% of the respondents indicated self-owned and drive vehicle, 12.6% indicated friends owned and drive vehicle, while 22.3% indicated the union's owned vehicle. The remaining 33.0% and 4.9% accounts for a franchise and cooperative vehicles respectively. However, it is worthy to note that as big as the metropolitan area is, there is absolutely no government support and a subsidized vehicle in use for commercial transportation operation the study area. Meanwhile, the conventional public transportation scheme in the city is in a state of near collapse. Consequently, this gap left the city public transportation operation in a state of obfuscation.

Table 1. Motorists Profile

Gender	**Freq.**	**%**	**Educational Level**	**Freq.**	**%**
Male	334	94.6	No Formal Education	85	24.0
Female	19	5.4	Primary/Secondary	184	52.0
Total	353	100	National Diploma	61	17.4
Age	**Freq.**	**%**	Tertiary Degree	23	6.6
< 25years	64	18.0	Total	353	100
25 – 35 years	150	42.7	**Average daily income**	**Freq.**	**%**
36- 45 years	92	26.0	Below #2,000	20	5.8
Above 60 years	47	13.3	#2,000 – #4,000	45	12.6
Total	353	100	#4,001 – #6,000	141	39.9
Vehicle Ownership	**Freq.**	**%**	Above 6,000	147	41.7
Self-owned and drive	96	27.1	Total	353	100
Friend's owned and drive	45	12.7	**Marital status**	**Freq.**	**%**
Union's owned	79	22.4	Single	73	20.7
Franchise	116	33.0	Married	241	68.3
Cooperative Society	17	4.8	Divorced	34	9.6
Total	353	**100**	Widow/ widower	5	1.4
			Total	353	100

Authors' Fieldwork, 2019

The investigation conducted showed a clear variation in the motorists' patronage along the seven classified routes used for this survey. Based on the data presented in Table 2, Route 1, Route 4 and Route 5 are mostly plied by the commercial motorists 30.9%, 24.4% and 19.5% respectively, while less than 10% of the sampled motorists do ply Route 2, Route 3, Route 6 and Route 7 on daily basis. Accordingly, the study revealed that the seven screened routes are prominent principal routes in Ibadan metropolis attracting a significant proportion of motorists and commuters daily. However, based on field observation, these routes are without intelligent traffic devices and electronic traffic calming and monitoring devices despite the high volume of traffic plying them on daily basis.

Table 2. Route choice by motorists

Routes	Freq.	Per cent
Route 1: Iwo road/Challenge	109	30.9
Route 2: Beere/Oje/Iwo road	25	7.1
Route 3: Beere/Yemetu/UI/Ojo	33	9.3
Route 4: Ojo/UI/Sango/Dugbe	86	24.4
Route 5: Challenge/Ring road/Dugbe	69	19.5
Route 6: Dugbe/Apata/Omi Adio	20	5.7
Route 7: Dugbe/Eleyele/Sango	11	3.1
Total	353	100

Authors' Fieldwork, 2019

Also, different reasons are given for the choice of routes frequently plied by sampled motorists. As shown in Table 3, 24.3% plies the choice route for personal safety reason, while more than half (53.4%) considered patronage volume that is, because of the high volume of passengers commuting along the corridor as the reason for their route choice. Also, only 2.9% complied with government allocated routes, while the remaining 19.4% has to comply with the vehicle's owner in plying routes for commercial operations. This shows that route control by government and transport administrator is less effective as commercial motorists considered many other things before servicing route that interests them. Ironically, this observed dilemma no doubt has a huge effect on the trip distribution pattern in the city as some routes are underutilized while some are over-utilized leading to congestion along these corridors.

Table 3. Reason for the route choice

Reasons	Freq.	Per cent
Personal safety	86	24.3
Government allocation	10	2.9
Vehicle's owner directive	68	19.4
Patronage volume	189	53.4
Total	353	100

Authors' Fieldwork, 2019

There are four categories of vehicles being used for commercial operations along the seven screened routes in the study area and the most-used are shown in Table 4. In this regard, 29.1% are car/taxi, 35.9% are motorcycle, 20.4% are tricycle, while the remaining 14.6% are minibus. This shows that the mass transit system is not in operation along the study route. Hence, the domineering of the routes by para transit modes with low carrying capacity with a disorganized way of operations and illogical parking system.

Table 4. Type of vehicle

Types	Freq.	Per cent
Car/taxi	103	29.1
Motorcycle	127	35.9
Tricycle	72	20.4
Minibus	52	14.6
Total	353	100

Authors' Fieldwork, 2019

The period of operations of the motorists is classified into three as presented in Table 5. Accordingly, only 46.6% do operate within the morning period of 6 am-11:59 am only, while a quarter (25.2%) operates within the afternoon period of noon -6pm only and the remaining 28.2% operates within the evening period only. However, this data technically revealed that a vehicle may probably be operated by three different drivers in a day due to the poor socio-economic status of the city as well as the huge demand of urban mobility needs.

Table 5. Periods of operation

Period	Freq.	Per cent
Morning (6-12noon)	164	46.6
Afternoon (12-6 pm)	89	25.2
Evening (6-11 pm)	100	28.2
Total	353	100.0

Authors' Fieldwork, 2019

4.2 Factors Aiding Traffic Congestion in Ibadan

Based on this estimation, it is observed in Table 6 that 3.281 is the Mean Weighted Value MWV of the identified factors aiding traffic congestion in the study area. The factors are broadly categorized into three namely worsening, moderate and below average. With this, the worsening factors aiding traffic congestion has Relative Index Mean Value RIM that is greatly higher than the Mean Weighted Value MWV, while the moderate factors are observed with a slightly higher value than the MWV and factors with a value below the MWV are factors that less contributory to the traffic congestion within the metropolis. However, faulty junction and the intersection has the highest potent value of 3.586 exceeding the MWV and is closely followed by unprofessional conducts and excesses of traffic officers (3.558) (see Figure 2 & 3). Next to that are the unguided activities of commercial motorcycle operators (3.530); persistent queue indiscipline of motorists (3.524); deplorable road conditions (3.490); and poorly design speed breaker and bumps (3.402). Also, trucking operators' exuberance/intolerance (3.343); poor routes connectivity and carriage capacity (3.275) (see Figure 2); street trading (3.265) and On-street parking/ parking difficulties (3.265) are moderately aiding factors of traffic congestion (see Figure 2), while poor interchange design and capacity (3.303), traffic crashes/incidents (3.006), activities of tricycle operations (2.992) and road encroachment (2.909),

DOI: 10.26552/tac.C.2020.1.6

as well as the activities of the rickety vehicles (2.909), are less impactful factors aiding traffic congestion along the selected corridors in Ibadan metropolitan area of Oyo State, Nigeria. Meanwhile, it is worthy to note that these factors are not just aiding traffic congestion but also contributing to the unpredictable travel time which relatively affecting the socio-economic development as well as sustainable spatial interaction in the city.

Table 6: Factors aiding traffic congestion in Ibadan

S/N	Factors	VH-4	H-3	L-2	VL-1	TWV	RIV	MWV	RK
1	Traffic crashes/incidents	400	540	96	25	1061	3.006		12
2	Faulty junction/ intersection	920	300	46	0	1266	3.586		1
3	Excesses of Traffic officers	940	270	36	10	1256	3.558		2
4	On-street parking/ parking difficulties	788	285	56	33	1162	3.292		9.5
5	Poor routes connectivity and carriage capacity	740	360	36	30	1166	3.303		8
6	Activities of motorcycles operators	940	240	56	10	1246	3.530		3
7	Street trading	788	285	56	33	1162	3.292		9.5
8	Queue indiscipline	940	234	60	10	1244	3.524	3.281	4
9	Trucking operators' exuberance/intolerance	788	300	72	20	1180	3.343		7
10	Activities of tricycles operators	380	540	116	20	1056	2.992		13
11	Deplorable roads	868	285	76	3	1232	3.490		5
12	Poor interchange design and capacity	420	600	36	30	1086	3.076		11
13	Speed breakers/ bumps	820	300	66	15	1201	3.402		6
14	Road encroachment	308	570	126	23	1027	2.909		14.5
15	Activities of rickety vehicles	308	570	126	23	1027	2.909		14.5

Authors' Fieldwork, 2019

Figure 2. A section of Iwo road with faulty intersections and unprofessional conducts of traffic officers

Figure 3. A section of Beere/Yemetu-UI/Ojo road showing unguided packing activities and road encroachment

4.3 Effectiveness of existing traffic congestion measures in Ibadan

Furthermore, the analysis of the appropriateness of eleven (11) existing traffic congestion measures in Ibadan was presented in Table 7. Findings revealed 3.018 has the Mean Weighted Value MWV. Accordingly, the congestion measures such as electronic traffic signalization with Relative Index Mean Value RIM of 3.558 was observed to be the first rated existing measure that greatly impacts traffic congestion minimization in the study area despite the poor condition of most of the installed related devices. Next to this are the law enforcement and regulation (3.499); road expansion/ dualisation (3.431); public enlightenment (3.292); arterial road maintenance (3.139); road channelization (3.076); and construction of overhead bridges and flyovers (3.037) which are rated second, third, fourth, fifth, sixth and seventh weighted factors respectively and are observed to be appro-

priate reduction measures for traffic congestion in the city. Nevertheless, underpass (2.983), increased manual traffic control measures (2.890), the introduction of mass transport operation (2.159) and increased construction of speed breaker/ bumps (2.136) are seen as grossly ineffective. Hence, their ineffectiveness and unsuitably still applied to the curtailment of worsening traffic congestion in the modern city of Ibadan.

Table 7. Effectiveness of existing traffic congestion measures in Ibadan

S/N	Measure	A-4	SA-3	SI-2	I-1	TWV	RIM	MWV	RK
1	Electronic traffic signalization	920	270	66	0	1256	3.558	3.018	1
2	Road expansion/ dualisation	860	285	46	20	1211	3.431		3
3	Increased speed breaker/ bump	84	225	376	69	754	2.136		11
4	Road channelization	400	570	106	10	1086	3.076		6
5	Public enlightenment	788	285	56	33	1162	3.292		4
6	Law enforcement/ regulation	880	276	76	3	1235	3.499		2
7	Underpass	320	570	160	3	1053	2.983		8
8	Arterial road maintenance	420	576	112	0	1108	3.139		5
9	Increased manual control measures	280	546	186	8	1020	2.890		9
10	Construction of overhead bridges and flyovers	424	540	82	26	1072	3.037		7
11	Mass transport operation	88	225	386	63	762	2.159		10

Authors' Fieldwork, 2019

4.4 Intelligent Transport System ITS for Traffic Congestion Management

With the ineffectiveness of the traditional traffic management system and existing traffic congestion measures such as the construction of flyovers, road channelization, one-way system, traffic signals, underpass, speed breaker and relocation of neighbourhood market away from roadways in enhancing persistent traffic congestion in the city, the need for a paradigm shift in these common approaches smart transportation initiatives become crucial. Hence, the adoption of modern smart traffic control measures in the city is inevitable. As a result, Table 8 presents the analysis of the disposition of respondents to the deployment Intelligent Transport System ITS for traffic congestion and flow management in the metropolitan city of Ibadan, Nigeria. The result of the analysis produced Mean Weighted Value estimated at 3.261. Accordingly, respondents strongly agree and favourably disposed to the use of real-time traffic signal devices which has highest Relative Index Mean Value RIM of 3.609 and this is strongly followed by automated travel advisory system (TAS) devices (3.595). Also, the use of automated road congestion pricing devices (3.581); intelligent traffic information devices (3.567); video surveillance sensors /CCTV (3.501); GPS based automated vehicle locators (3.343); intelligent traffic management centre (3.314) are also relatively disposed to use by respondents considering their relative index mean value greater than the Mean Weighted Value of 3.261 unlike other devices that scored below the MWV indicating less disposed devices including automated travel speed and time locator, automated parking system, e-ticketing and automated fare collection devices etc.

Like Reference [20, 21, 24] observed, most congested intra-city routes in Ibadan city include University of Ibadan-Dugbe Route, Dugbe-Apata Route, Olomi/Odinjo/Beere road, Challenge/Podo road, Challenge/Molete/Bere road, Inalende/Oritamerin route, Lagos/Ibadan Tollgate, Iwo road junction, Dugbe/Oke-Ado/Molete route and Challenge-Molete-Beere route, Mokola-UCH/Total Garden-Gate route, Beere-Oje-Iwo road, Beere-Total garden secretariat-U.I. road, Sango-Eleyele road, Eleyele-Dugbe road, Eleyele-Ologuneru road, Apete-Ijokodo-Sango road, Ojo/U.I.-Mokola-Dugbe road and Apata-Dugbe road etc. These routes are congested with long hours delay particularly during the morning, afternoon and evening peaks of the week coupled with longer transit time which sometimes led to terrific and unpredictable traffic situations during weekdays and weekend rush. Meanwhile, it is crystal clear that most of these routes lacks functional Intelligent Transport System. The installed ITS devices including automated traffic calming devices are totally in degraded state (Figure 1). This perhaps is a contributing factor causing the unwanted traffic situation within the observed city.

DOI: 10.26552/tac.C.2020.1.6

Table 8. Smart transport technologies

S/N	Technology	SA-4	A-3	D-2	SD-1	TWV	RIM	MWV	RK
1	Automated travel advisory system (TAS) devices	920	324	20	5	1269	3.595	3.261	2
2	Video surveillance sensors /CCTV	860	300	76	0	1236	3.501		5
3	Automated vehicle weight and type detector	280	564	154	18	1016	2.878		13
4	Traffic calming devices	260	570	180	8	1018	2.884		12
5	GPS based automated vehicle locators	768	309	90	13	1180	3.343		6
6	Intelligent traffic information devices	900	309	50	0	1259	3.567		4
7	E-ticketing and automated fare collection devices	280	600	140	13	1033	2.926		11
8	Electric-powered vehicles	300	594	154	3	1051	2.977		10
9	Automated parking system	288	738	70	0	1096	3.105		9
10	The intelligent traffic management centre	768	309	70	23	1170	3.314		7
11	Real-time traffic signal devices	920	324	30	0	1274	3.609		1
12	Automated road congestion pricing devices	920	324	10	10	1264	3.581		3
13	Automated travel speed and time locator	288	744	66	0	1098	3.110		8

Authors' Fieldwork, 2019

4.5 Disposition to the Use of Intelligent Transport System ITS and other Smart Transport Technologies STT

The results of analyzed data on the disposition to the use of ITS devices and other smart transport technologies by motorists are presented in Table 9. Findings show that 18.5% resolved that real-time traffic signal devices are not necessary, while the majority (61.5%) expressed its necessity and willingness to use, and 13.2 % indicated necessary but unwilling to use, and the remaining 6.8% was indifference. On the automated traffic calming devices, 15.5% noted it as unnecessary, the majority (42.8%) indicated necessary and willing to use, while 9.7 equally support its necessity but unwilling to use and the remaining 32.0% is indifference to automated traffic calming devices. Likewise, 18.4% resolved that electronic road/ congestion pricing devices as unnecessary in the city, the majority (50.5%) see it as necessary and willing to use, while 6.8% also expressed its necessity but unwilling to use and the remaining 24.3% were indifferent in the disposition to the use of electronic road pricing devices as a ITS devices in the study area. Concerning electronic traffic monitoring and surveillance devices (sensor cameras /CCTV), the majority (41.8%) find it necessary and willing use the devices along the routes, 33.0% of the respondents noted the devices are unnecessary along the traffic corridors, 5.8% noted necessary but unwilling to use or obey if install along the route corridors, while 19.4% of the respondents were indifferent.

Table 9 also shows that 27.9% viewed automated travel advisory system (ATAS) as unnecessary, the majority (49.8%) indicated that incident detection and management devices are necessary and willing to use it, while 9.7% claimed it as necessary but unwilling to use and the remaining 12.6% were indifferent. On the electric-powered vehicles, majority 55.3% resolved that the electronic parking system is unnecessary, 31.1% see it as necessary and willing to use, while 10.7% see it as necessary but unwilling to use and the remaining 2.9% were indifferent. Also, analyzed data on automated parking system revealed that 18.4% see it as unnecessary, the majority (50.5%) view it as necessary and willing to use, while 6.8% claimed it as necessary but unwilling to use and the remaining 24.3% were indifferent. Findings on GPS based automated vehicle locators revealed that 9.7% view it as unnecessary, 54.0% view it as necessary and willing to use, while 18.8% also noted it necessary but unwilling to use and the remaining 17.5% were indifferent. More so, the majority (50%) of respondents resolved that intelligent traffic management centre is necessary and willing to use, 27.9% noted it is not necessary, 9.7% noted necessary but not willing to use, while 12.6% were indifferent. Similarly, data on intelligent traffic information devices shows that majority over 60% of respondents found these related devices necessary and willing to use, 18.5% noted they are not necessary, 13.2 % noted necessary but not willing to use, while 6.8% were indifferent. In the same vein, the majority (54%) of the respondents observed that it is necessary and willing to use automated travel speed and time locator along the transit routes, 9.7% noted not necessary, 18.8% respondents noted necessary but not willing to use, while 17.5% respondents were indifferent. In other words, data on automated vehicle weight and type detector show that majority over 50 % found it not unnecessary along transit routes, 31.1% found it necessary and willing to use, 10.7 % found it necessary but unwilling to use while less than 3% respondents were indifferent. In the same vein, the majority (about 40%) of the respondents observed that the e-ticketing and automated fare collection system is unnecessary, about 30% noted necessary and willing to use, 20.4% found it necessary but unwilling to use, while 14.6% of the respondents were indifferent.

Table 9: Disposition to Use Improved Intelligent Transport System ITS Devices

S/N	Smart Technologies	Not necessary		Necessary and willing to use		Necessary but unwilling to use		Indifference		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	Real-time traffic signal devices	65	18.5	217	61.5	47	13.2	24	6.8	353	100
2	Automated traffic calming devices	55	15.5	151	42.8	34	9.7	113	32	353	100
3	Electronic road/congestion pricing devices	65	18.4	178	50.5	24	6.8	86	24.3	353	100
4	Video surveillance sensors /CCTV	116	33	148	41.8	20	5.8	68	19.4	353	100
5	Automated travel advisory system (ATAS)	98	27.9	176	49.8	34	9.7	44	12.6	353	100
6	Electric-powered vehicles	195	55.3	110	31.1	38	10.7	10	2.9	353	100
7	Automated parking system	65	18.4	178	50.5	24	6.8	86	24.3	353	100
8	GPS based automated vehicle locators	34	9.7	191	54	66	18.8	62	17.5	353	100
9	The intelligent traffic management centre	98	27.9	176	49.8	34	9.7	44	12.6	353	100
10	Intelligent traffic information devices	65	18.5	217	61.5	47	13.2	24	6.8	353	100
11	Automated travel speed and time locator	34	9.7	191	54	66	18.8	62	17.5	353	100
12	Automated vehicle weight and type detector	195	55.3	110	31.1	38	10.7	10	2.9	353	100
13	E-ticketing and automated fare collection	127	35.9	103	29.1	72	20.4	52	14.6	353	100

Authors' Fieldwork, 2019

However, considering the responses received from Table 9, the majority of the respondents found most of the ITS and other smart transport technologies necessary. Based on these findings, it can be inferred that the motorists are well aware of the general importance and benefits of the smart transport technologies considering the response rate, although the percentage of indifferent in the use of some devices are still high. This perhaps is not unconnected to the various classifications and unawareness of most of the ITS devices in the study area. Meanwhile, it is clear from the findings that majority of the motorist are willing to use the ITS and/or smart transport technologies if installed along the transit routes in the city to minimize the traffic congestion and longer travel time within the city.

4.6 Hypothesis Testing

Association between Educational Level and Use of Intelligent Transport System ITS Devices using

Cross-tabulation, Pearson Chi-Square Test and Fisher's Exact Test

Further investigations were conducted on the influence of respondents' level of education and the use ITS devices in the study area. Cross-tabulation was used in the descriptive analysis between the categorical variable (education level) and a group of independent variables measured on a dichotomous form (unnecessary/indifferent = 0 and necessary willing to use and necessary but not will use = 1). Based on the cross-tabulation results shown in Table 10, it can be deduced that respondents with formal education scored a high percentage than those with no formal education across all the observed ITS devices. By implication, respondents with formal education are more informed about the necessity of ITS devices in mitigating increasing traffic congestion and flow in the city of Ibadan and equally involved in the decision to use or not the ITS devices in the study area. However, those with no formal education were less informed and involved in the decision to use or not the ITS devices as most of their scores to each smart tools were less than ten per cent (20%).

Nevertheless, the observed statistical relationship between a categorical variable (educational level of respondents) and the distribution of another group of variables (use of ITS devices) through the use of Pearson Chi-Square Test and Fisher's Exact Test were also presented in Table 10. The Pearson Chi-Square Test and Fisher's Exact Test were used to establishing an independency test results on the influence of respondents educational level on the use of ITS devices. Findings show that twelve (12) out of the thirteen (13) examined ITS devices were associated with or influenced by the level of education of the respondents (Table 10). These findings were observed and confirmed to be statistically significant as their calculated significant values for both the Pearson Chi-Square Test and the Fisher's Exact Test were less than the table significant value of 0.05 (Table 10). Hence, the rejection of the null hypothesis (H0), and acceptance of the alternative hypothesis (H1) which states that the use Intelligent Transport System ITS is a function of respondents' level of education. By implication, it can be inferred that the use ITS devices in the study area is being influenced by the level of education of users most especially the motorist. In other words, the real-time traffic signal devices of the examined ITS devices is observed not to be statistically

DOI: 10.26552/tac.C.2020.1.6

significant as its calculated significant values for Pearson Chi-Square Test (0.516) and Fisher's Exact Test (0.509) were far above the table significant value (0.05) see Table 10. Hence, the use of real-time traffic signal devices is not a function of the level of education of respondents, rather it is conditioned on other factors that include but not limited to the nature and situation of traffic along the route corridors. However, the twelve (12) ITS that are observed to the significant that is influenced by the level of education of respondents includes the use of automated traffic calming devices (0.02); electronic road/congestion pricing devices (0.03); video surveillance sensors /CCTV (0.04); automated travel advisory system (ATAS) (0.00); electric-powered vehicles (0.00); automated parking system (0.00); GPS based automated vehicle locators (0.00); intelligent traffic management centre (0.00); intelligent traffic information devices (0.00); automated travel speed and time locator (0.00); automated vehicle weight and type detector (0.00); and E-ticketing and automated fare collection (0.03) for both Pearson Chi-Square Test and Fisher's Exact Test.

Table 10. Cross-tabulation and Chi-Square Tests of Educational Level and the Use of ITS Devices

		Educational Level					**Pearson Chi-Square**		**Fisher's Exact Test**	
Technology	**Readiness**	No Formal Education	Primary/ Secondary	National Diploma	Tertiary Degree	Total	Value	Sig.	Value	Sig.
Real-time traffic signal devices	Unnecessary	5.7	12.2	7.4	0.0	25.2	2.307	0.516	2.346	0.509
	Necessary	18.4	39.9	9.9	6.5	74.8				
	Total	24.1	52.1	17.3	6.5	100				
Automated traffic calming devices	Unnecessary	10.2	23.8	8.5	5.1	47.6	9.948	0.019	10.030	0.018
	Necessary	13.9	28.3	8.8	1.4	52.4				
	Total	24.1	52.1	17.3	6.5	100				
Electronic road/congestion pricing devices	Unnecessary	12.7	21.0	5.4	3.7	42.8	9.225	0.026	9.183	0.026
	Necessary	11.3	31.2	11.9	2.8	57.2				
	Total	24.1	52.1	17.3	6.5	100				
Video surveillance sensors /CCTV	Unnecessary	14.7	26.9	6.5	4.0	52.1	8.596	0.035	8.547	0.035
	Necessary	9.3	25.2	10.8	2.5	47.9				
	Total	24.1	52.1	17.3	6.5	100				
Automated travel advisory system (ATAS)	Unnecessary	12.2	18.4	3.4	6.2	40.2	45.736	0.000	48.250	0.000
	Necessary	11.9	33.7	13.9	0.3	59.8				
	Total	24.1	52.1	17.3	6.5	100				
Electric-powered vehicles	Unnecessary	9.9	34.0	13.3	0.8	58.1	41.999	0.000	42.568	0.000
	Necessary	14.2	18.1	4.0	5.7	41.9				
	Total	24.1	52.1	17.3	6.5	100				
Automated parking system	Unnecessary	16.1	15.6	5.4	5.7	42.8	54.665	0.000	55.201	0.000
	Necessary	7.9	36.5	11.9	0.8	57.2				
	Total	24.1	52.1	17.3	6.5	100				
GPS based automated vehicle locators	Unnecessary	4.5	18.4	4.2	0.0	27.2	17.953	0.000	20.369	0.000
	Necessary	19.5	33.7	13.0	6.5	72.8				
	Total	24.1	52.1	17.3	6.5	100				
The intelligent traffic management centre	Unnecessary	13.0	15.9	4.8	6.5	40.2	52.209	0.000	56.400	0.000
	Necessary	11.0	36.3	12.5	0.0	59.8				
	Total	24.1	52.1	17.3	6.5	100				
Intelligent traffic information devices	Unnecessary	5.7	12.2	7.4	0.0	25.2	18.019	0.000	19.459	0.000
	Necessary	18.4	39.9	9.9	6.5	74.8				
	Total	24.1	52.1	17.3	6.5	100				

Automated travel speed and time locator	Unnecessary	11.0	7.4	2.3	6.5	27.2	98.535	0.000	94.451	0.000
	Necessary	13.0	44.8	15.0	0.0	72.8				
	Total	24.1	52.1	17.3	6.5	100				
Automated vehicle weight and type detector	Unnecessary	17.0	25.5	9.1	6.5	58.1	29.204	0.000	34.071	0.000
	Necessary	7.1	26.6	8.2	0.0	41.9				
	Total	24.1	52.1	17.3	6.5	100				
E-ticketing and automated fare collection	Unnecessary	14.4	24.4	7.4	4.5	50.7	8.963	0.029	8.896	0.030
	Necessary	9.6	27.8	9.9	2.0	49.3				
	Total	24.1	52.1	17.3	6.5	100				

Authors' Fieldwork, 2019

5. Conclusion and Recommendations

The study has examined traffic congestion and Intelligent Transport System ITS in fast-growing Nigeria cities using Ibadan city as a reference point. It investigated the motorist profile and route characterization; identified factors aiding traffic congestion, the effectiveness of the existing traffic control measures and repeated approaches being used for its curtailment of traffic congestion in the city, the performance and disposition to the use of ITS devices in the study area. This has established that the existing mechanism in place as a congestion control mechanism remained ineffective as the strategies are being recycled for several years with the same results. It also underscores the rationale for a paradigm shift in the provision of better strategies for improving traffic congestion management in cities through the adoption and acceptance of the use of Intelligent Transport System ITS. This study affirmed that the persistent traffic congestion in Ibadan is being aggravated by ineffective control measures put in place aside from faulty junctions and intersections, unprofessional ethics and excesses of traffic officers, narrow road, haphazard on-street parking, neglect of pedestrian facilities, deplorable road, absence of road discipline, poor public transport, activities of motorcycles and tricycle operators as well as the indiscriminate location of traffic generating land use along the major roads/intersections.

Accordingly, road dualisation, human control, installation of the traffic signal, construction of flyover and underpass and other traditional and existing traffic control measures have not been able to manage traffic congestion to a tolerable level in the city; hence, the conclusion that they are inaccurate and inappropriately suitable to meet modern traffic congestion and its associated challenges in Nigeria cities. Therefore, the need to enhance intra-city movement and flow for efficient service delivery calls for improved measures such as the use of improved Intelligent Transport System.

This study concludes that traffic congestion and its accompanying challenges are increasingly worsening in Ibadan 42 years after the city hosted the first attention on transportation development in the country. As a result, the unlimited prospects which are domicile in smart technologies vis-à-vis ITS have to be holistically explored for improved traffic congestion management and flow movement in the city. Considering the various issues guiding smart transport, it is not an overstatement that Nigeria cities partially or wholly practice traffic congestion control based on discretion, political goal and for revenue drives, unlike the best practices as presented in the case of European cities where attention is been shifted to smart transport to minimize congestion and improved flow.

Therefore, smart transport components are recommended as a paradigm shift to traditional traffic congestion measures being used in Ibadan city and cities with similar traffic dilemma. Such measures include the use of Video Surveillance and Response (VSR) which involves continuous monitoring of key network locations to determine if traffic is moving or encountering congestion. Such monitoring is done with strategically located sensors or cameras, including different radar sensors, infrared and visible spectrum imaging and laser technology to observe flow interruptions and threats continuously. Also, informational signing such as variable messages which include electronic changeable message signs along the major roads and selected corridors to assist drivers regarding major congestion points on the road ahead is essential. These signs often give directions as to ways to avoid upcoming congestion points related to accidents, delay, congestion and the likes.

Also, the establishment of a Traffic Information Center (TIC) to be manned by personnel on 24 hours basis is extremely essential. This shall usually connect with other outside fixed and semi-fixed installations as well as mobile technologies from where traffic flows are being monitored and information disseminated to field units. Such TIC should be connected with VSR, CCTV, GPS, trackers, webcams, navigation system and many other technologies. As a result, strong political will is needed from the government by investing financially, legislatively, humanly and technologically in smart transport technologies. This will enhance transport development and management generally as a major pre-requisite for ICT enabling traffic management that will usher efficient service delivery. Finally, the nature of traffic flow in an area is usually a reflection of its pattern and structure of land uses. Therefore, exigency in the provision and enforcement of Intelligent Transport System ITS devices would be efficient in land use planning activities, spatial organisation and other urban metaphor including smart city,

DOI: 10.26552/tac.C.2020.1.6

green city and liveable city if fully embraced and practised. As such, the need to properly integrate spatial planning using technological driven transport measures is unavoidably crucial to ensure free flow and sustainable intra-and-inter urban movements in the study area, and the nation at large, while taking into consideration, constraints to the adoption of ITS applications in Nigerian urban transport system such as epileptic electricity supply, non-availability of reliable traffic data and weak internet facility.

REFERENCES

[1] Adeniji, K., "Transport challenges in Nigeria in the next two decades", Monograph of Nigeria Institute of Social and Economic Research (NISER), vol.1, no.3, pp.40-67, 2000.

[2] Adesanya, A., "Analysis and management of transport sector performance and its intersectoral linkages", in lectures Delivered at the Training Programme on Sectoral Policy Analysis and Management, Ibadan, Nigeria, June 21-July 9, Ibadan: Nigeria Institute of Social and Economic Research (NISER), 2004.

[3] Akanmu, A. and Agboola, D., "Basic elements of traffic survey", Penthouse Publications, Ibadan, 2015.

[4] Akpoghomeh, O. S., "The terror of transport and the transportation of terror", an inaugural lecture University of Port Harcourt, Nigeria, University of Port Harcourt Press, Port Harcourt, 2012.

[5] Amiegbebhor, D., "Most significant causes of traffic congestion in Port Harcourt metropolis, Nigeria", International Journal of Academic Research and Reflection, vol.6, no.6, pp.8-17, 2018.

[6] Badejo, B. A., "Transportation: removing the clogs to Nigerian's development", Anchorage Press and Publishers, Lagos, 2011.

[7] European Commission, "Mobilizing intelligent transport systems for European cities", European Commission Staff Working Document, Brussels, 2013.

[8] Falola, T., "Ibadan warrior traditions and the anatomy of success", in lecture delivered at the 2009 Adegoke Adelabu Memorial Lectures at Mapo Hall, Ibadan, June 2009, University of Ibadan Press, Ibadan, 2009.

[9] Fourchard, L., "The case of Ibadan, Nigeria", University of Ibadan Press, Ibadan, 2000.

[10] Gbadamosi, K.T. and Akanmu, A.A., "Counterproductive nature of transportation externalities on the livability of Nigeria cities", in proceeding of the American Association of Geographer Annual Meeting, 3-7 April 2019, Washington D.C.: American Association of Geographer, 2019.

[11] Geenhuizen, M. V., "ICT application on the road to sustainable urban transport", European Transport, vol.41, pp.47-61, 2009.

[12] Harriet, T., Poku, K. and Emmanuel, A. K., "An assessment of traffic congestion and its effect on productivity in urban Ghana", International Journal of Business and Social Science, vol.4, no.3, pp. 225-234, 2013.

[13] Jain, V., Sharma, A. and Subramanian, L., "Road traffic congestion in the developing world", in proceedings of DEV'12, March 11-12, ACM Publisher, Atlanta, GA, 2012.

[14] Lagos State Government Ministry of Economic Planning & Budget, "The socio-economic costs of traffic congestion in Lagos", Economic Intelligence Unit Working Paper Series No 2: Lagos: Lagos State Government, 2013.

[15] Ministry of Works and Transport, "Draft report on Ibadan traffic control", Oyo State Government, Ibadan, 2001.

[16] Mitchell, W. J., "Smart city 2020", unknown, 2012. Accessed at www.metropolismag.com/story.

[17] Nwakairu, J. N., Ohagwu, C. J. and Ani, A. O., "Possibilities of ICT as a means of poverty alleviation for rural dwellers in Nigeria", in proceedings of 3rd International Conference of WASAE. In: 9th International Conference of NIAE, January 25-29, Obafemi Awolowo University, Ile-Ife, Nigeria. Obafemi Awolowo University Press, pp. 408-413., 2009.

[18] Ogunsanya, A. A., "Makers and breakers of cities", an inaugural lecture of University of Ilorin, Nigeria. University of Ilorin Press, Ilorin, 2002.

[19] Ogunsesan, D. K., "Beautiful city, comfortable life: issues and challenges of Ibadan region, Nigeria", in lecture delivered at the Annual General Meeting, Investiture of New Executives and Award Night/Lecture of Ibadan Descendants Union, 26 February 2011, Ibadan Descendants Union, Ibadan, 2011.

[20] Ogunsesan, D. K. and Akanmu, A. A., "Hindrance to traffic movement in Ibadan metropolitan area: challenges and solutions", in lecture delivered at the Faculty of Environmental Studies Seminar Series of the Polytechnic, Ibadan, Nigeria, 19th May 2010, The Polytechnic of Ibadan Press, Saki, 2010.

[21] Ogunsesan, D. K., Akanmu, A. A. and Ogunsesan, A. S., "Appraising land-use and Ibadan traffic paralysis", Generalities Journal, vol.1, no.3, pp.85-93, 2012.

[22] Okoko, E., "Spatial Interaction: the quintessence of urban mobility", an inaugural lecture series 98 of Federal University of Technology, Akure, Nigeria, Federal University of Technology Akure Press, Akure, 2018.

[23] Onakomaiya, S. O., "Unsafe at any speed, toward road transportation survival", an Inaugural lecture of University of Ilorin, University of Ilorin Press, Ilorin, 1988.

[24] Orioke, J. M. A., "Traffic education and traffic flow in Ibadan city", in proceedings of Conference of the Nigerian Institute of Social and Economic Research at the University of Ibadan, 4-9 January, Nigerian Institute of Social and Economic Research (NISER), Ibadan, 1977.

[25] Oyesiku, O. O., "From womb to tomb", an inaugural lecture of Olabisi Onabanjo University, Ago-Iwoye, Nigeria, Olabisi Onabanjo University Press, Ago-Iwoye, 2002.

[26] Salisu, U.O., "State of transport administrative structure in Lagos, Ogun, and Oyo States, Nigeria", Journal of Spatial and Organizational Dynamics, vol.7, no.1, pp. 68-85, 2019.

[27] Shepelev, V., Aliukov, S., Nikolskaya, K., Das A., and Slobodin, I. "The use of multi-sensor video surveillance system to assess the capacity of the road network", Transport and Telecommunication, vol.21, no.1, pp.15–31, 2020. DOI 10.2478/ttj-2020-0002

[28] Shimizu, T., Shomura, Y., Masukawa, H. and Takeda, Y. Traffic management solutions for the social innovation business. Hitachi Review, vol.63, no.1, pp.52-56, 2014.

[29] Wen, L. Kenworthy, J., Guo, X. and Marinova, D., "Solving traffic congestion through street renaissance: a perspective from dense Asian cities", Urban Sci. vol.3, no.8, pp.1-21, 2019 DOI:10.3390/urbansci3010018.

Constraint Management - the Review

Iwona Tomaszewska[1]

[1]Faculty of Management, Warsaw University, 02-678 Warsaw, Poland

Abstract Constraint management has evolved into a whole system philosophy. It has a manufacture component, but the methodology focus remains at the system level. This article has presented briefly the main assumptions of Theory of Constraints (TOC), which concentrates on the process that slows the speed of production through the system. It is a simple overview of the types of constraints and tools of constraint management, looking at the background. It presents five crucial focusing steps of Theory of Constraints. It also shows the comparison TOC with Six Sigma and Lean Thinking.

Key words theory of constraints, constraint management, system as chains, lean thinking, drum-buffer-rope, five focusing steps, systems approach, goals, production scheduling, critical chain.

JEL R49, R59

1. Brief Description of Constraint Management

Constraint management has grown out of the Theory of Constraints (TOC), a set of principles and concepts introduced by Eliyahu M. Goldratt, an Israeli physicist, in the 1980s in a book entitled The Goal [1, 2]. Goldratt developed three classes of tools, which will be described in detail in point 2. The theoretical principles and concepts into application was extended. In this part of the article types of constraints and assumptions of the constraint theory are presented.

1.1 Introduction

Theory of Constraints has evolved into a whole-system philosophy. It has a manufacture component (like for example in Lean Manufacturing) [3], but the methodology focus remains at the system level.

We define "system" in different ways. This could be the whole business, or it could be a strategic business unit, for example an independent division. It could also be one particular part in a division, though in this case some consideration of external dependencies is usually required. Goldratt characterized systems as chains. These, of course are chains of interdependency, not in the literal sense. They do not necessarily have to be a single sequence of links. The chains characterize the flow of work through the business system. Each link in the chain has a specific maximum capacity, and these capacities usually are different from one another.

Goldratt used the chain analogy to emphasize the concept of the weakest link. The strength of the entire chain is limited by the maximum strain the weakest link can stand. In the same way, the performance of a sequential flow system is limited by the least capable element of this system. The weakest link can occur anywhere in the chain of dependency. For example, limited capacity on a piece of manufacturing equipment might restrict output or sales might not be sufficient to fill up available capacity. In the first situation, the performance of the whole company (system) is limited by a physical resource. In the second, it is limited by external demand [4]. The strength of the chain is determined by the strength of its weakest link. The research shows that there is only one weakest link in a chain.

1.2. Types of Constraints

Identifying and breaking constraints become easier if there is an orderly way of classifying them. As it is known system constraints can be considered of two types - physical one and political one. Within these two broad categories, there are seven basic types of constraints [5]:

1. market - not enough demand for a product or service.
2. resource - not enough people, equipment, or facilities to satisfy the demand for products or services.
3. material - inability to obtain required materials in the quantity or quality needed to satisfy the demand for products or services.
4. supplier/vendor - unreliability (inconsistency) of a supplier or vendor, or excessive lead time in responding to orders.
5. financial - insufficient cash flow to sustain an operation. For example, a company that cannot produce more until payment has been received for work previously completed, because they might need that revenue to purchase materials for a firm order that is waiting.
6. knowledge/competence - knowledge: information or knowledge to improve business performance is not resident within the system or organization.

DOI: 10.26552/tac.C.2020.1.7

Competence: people do not have the skills necessary to perform at higher levels required to remain competitive.

7. policy - any law, regulation, rule, or business practice that inhibits progress to-wards the system's goal.

1.3. Four Assumptions of Constraint Theory

The Theory of Constraints is based on four assumptions, which are TOC principles and prescriptions for plenty of organizations as a system because [5]:

1. every system has a goal and necessary conditions that must be satisfied in order to achieve it. Effective effort to improve system performance is not possible without a clear understanding and consensus about what the goal and necessary conditions are.
2. the system optimum is not the sum of the local optima (efficiencies). In other words, the most effective system does not come from maximizing the efficiency each system component individually, without regard to its interaction with other components.
3. very few variables maybe only one-limit the performance of a system at any given time: This is equivalent to the "weakest link" concept discussed earlier.
4. all systems are subject to cause-and-effect. There are natural and logical consequences to any action, decision, or event. For these events that have already occurred, these consequences can be visually mapped to aid in situation or problem analysis. For those decisions that have yet to occur, or which are contemplated, the outcomes of these actions, decisions or events can be logically projected into the future and visually mapped.

The first presented above assumption states that every system has a goal and a set of necessary conditions that must be satisfied to achieve that goal. The most for-profit companies have something financial as their goal. Goldratt argues that the goal of for-profit companies is to "make more money, now and in the future". This, of course, would not be an appropriate goal for a government agency and therefore non-financial goals would have to be developed for such agencies. But it works quite well for most companies engaged in commercial business.

The importance of identifying a system (that means organization) is goal and necessary conditions become the standard by which all results are judged and all contemplated decisions are evaluated link. The organization knows that it is making progress in the right direction.

2. Tools of Constraint Management

A constraint management philosophy developed by Goldratt can be viewed as three separate but interrelated areas: logistics, performance measurement, and logical thinking. Logistics include drum-buffer-rope scheduling, buffer management, and VAT analysis. Performance measurement includes throughput, inventory and operating expense, and the five focusing steps. Thinking process tools are important in identifying the root problem (current reality tree), identifying and expanding win-win solutions (evaporating cloud and future reality tree), and developing implementation plan (prerequisite tree and transition tree).

To manage a system using the constraint philosophy, Goldratt created four functional tools: The five focusing steps for system improvement and The logical thinking process. This thinking process is unique problem-solving methodology that goes beyond problem identification and solution generation to verify and implement planning. He conceived drum-buffer-rope, a finite-capacity production management methodology. He created a scheduling tool called critical chain for project management environments.

2.1. The Five Focusing Steps

Theory of constraints (TOC) focuses on system improvement. A system is defined as a series of interdependent processes. An analogy for a system is the chain: a group of interdependent links working together toward the overall goal. The constraint is a weak link. The performance of the entire chain is limited by the strength of the weakest link. TOC concentrates on the process that slows the speed of product through the system. Below are the Five Focusing Steps of TOC which are explained in more detail in "The Goal" books [1, 6]:

1. identify the constraint of the system. The amount of work in queue ahead of a process operation is a classic indicator. Another example is where products are processed in batches.
2. decide how to exploit the constraint of the system. Once the constraint is identified, the process is improved or otherwise supported to achieve its utmost capacity with-out major expensive upgrades or changes. In other words, the constraint is exploited.
3. subordinate everything else to the decision in step 2. When the constraining process is working at maximum capacity, the speed of other subordinate processes is paced to the speed or capacity of the constraint. Some processes will sacrifice individual productivity for the benefit of the entire system. Subordinate processes are usually found ahead of the constraint in the value stream.
4. elevate the system's constraint. If the output of the overall system is not satisfactory, further improvement is required. Changes can involve capital improvement, reorganization or other major expenditures of time or money.
5. repeat means go back to step 1, but do not allow "inertia" to cause a system constraint. Once the first constraint is broken, another part of the system or process chain becomes the new constraint. Now is the time to repeat the cycle of improvement.

2.2. The Logical Thinking Process

The Theory of Constraints usually applies to running and improving an organization. It consists of Problem Solving and Management/Decision-Making Tools called the Think-

ing Processes (TP). TOC is applied to answer three questions essential to any process of ongoing improvement logically and systematically:

- What to change?
- To what to change?
- How to cause the change?

TOC postulates that the goal is to make money. It describes three ways to achieve this goal:

- Increase Throughput
- Reduce Inventory
- Reduce Operating Expense

2.3. Drum – Buffer - Rope production scheduling

Probably the best-known of the constraint management tools developed by Goldratt is called “Drum-Buffer-Rope” (DBR). The analogy was a description of a boy scout hike [1].

The drum was the pace of the slowest boy scout, which dictated the pace for the others. The buffer and rope have an additional meaning to ensure all the boy scouts walked at approximately the pace of the slowest boy. In a manufacturing or service company, the “drum” is the schedule for the resource or work center with the most limited capacity: the capacity constrained resource.

Starvation can result from upstream process variability, which might delay the transfer of work-in-process beyond its expected time. To ensure the capacity constrained resource is not starved for work, a buffer time is established to protect against variability. This is a period of time in advance of the scheduled “start processing” time that a particular job arrives at the capacity constrained resource.

The rope is constraint management’s safeguard against overloading the capacity constrained resource. In essence, it is a material release schedule that prevents work from being introduced into the system at a rate faster than the capacity constrained resource can process it. The rope concept is designed to prevent the backlog of work at most points in the system. This is important because work-in-process queues are one of the chief causes of long delivery lead times.

When the entire Drum-Buffer-Rope concept is applied, delivery reliability of 100 percent is not an unreasonable target and time of the process is reduced by 70 percent.

2.4. Critical Chain

Another valuable asset in the constraint management toolbox is called "critical chain". Critical Chain is also the title of the book by Goldratt [7]. Critical chain, is the first innovation in the field of project management in 50 years, and is ideally suited for high-uncertainty projects.

The critical chain concept provides an effective way to schedule the project activities by effectively accommodating uncertainty and resolving simultaneous needs contentions for the same resource. Critical Chain constitutes the application to onetime pro-jects of the same principles that Drum-Buffer-Rope applies to repetitive production [8]. The result of applying Critical Chain scheduling and resource allocation is a higher prob-ability of completing projects on time, and, in some cases, actually shortening total project duration. Originally applied to the management of a single project, the Critical Chain method has been expanded to multi-project environments, based on the concept of the "drum", described in Drum-Buffer-Rope.

Critical Chain tool has an input to make next edition the Project Management Body of Knowledge. Look at the distinguishes of Critical Chain from PERT/CPM and other traditional project management approaches presented below:

Critical Chain recognizes and accounts for some human behavioral phenomena that traditional project management methods do not. These phenomena include [9, 10]:

1. the tendency of technical professionals to "pad" their time estimates for individual tasks, in an effort to protect themselves from late completion.
2. "student syndrome" - waiting until the last minute to start working on a task with a deadline.
3. Parkinson’s Law - ensuring that an activity consumes every bit of the estimated time, no matter how quickly the associated tasks can actually be completed).
4. multitasking - the tendency of management to assign people more than one deadline activity simultaneously. Multitasking can create a devastating effect.

To solve this problem, Critical Chain takes most of the protective time out of each individual activity and positions some of it at key points in the project activity network: at convergence points and just ahead of project delivery. Since accumulating protection on an entire chain is much more effective than protecting every activity, only half of the aggregated “protective pad” extracted from individual activities is put back in at the key locations. The rest can contribute to earlier project completion. In traditional project execution, if protective time in a specific activity was not used, it would be lost forever - unusable by later activities that might need more protection than they were originally assigned. This formerly “lost time” is, in many cases, usable in Critical Chain.

Critical Chain devotes more attention to the availability of critical resources when they are needed for specific activities. Leveling the resources on any single project is mandatory [11]. The Critical Chain is really the longest sequence in the project that con-siders both dependent, sequential activity links and resource links. The critical path reflects only the sequential linking of dependent tasks.

3. Comparison TOC with Six Sigma and Lean Thinking

This part of article will focus on the basic ideas concern three improvement methodologies and will show a model to present their concepts, effects, similarities and differences. Table 1 describes the essence of each methodology. The Six Sigma and Lean thinking philosophies will be presented briefly, for sake of comparison, while Theory of Constraints

DOI: 10.26552/tac.C.2020.1.7

(TOC) the author has described in more detail above.

Six Sigma claims that focusing on reduction of variation will solve process and business problems. By using a set of statistical tools to understand the fluctuation of a process, management can begin to predict the expected outcome of that process. If the outcome is not satisfactory, associated tools can be used to understand the elements influencing that process further [12, 13].

Lean thinking is sometimes called lean manufacturing, the Toyota production system or other. Lean thinking emphasizes on the removal of waste, which is defined as anything not necessary to produce the product or service. One common measure is touch time - the amount of time the product is actually being worked on, or touched by the worker. Frequently the focus of lean thinking is manifested in an emphasis on flow [14, 15, 16].

There are five essential steps in lean thinking: identifying which features create value, identifying the sequence of activities called the value stream, making the activities flow, letting the customer pull product or service through the process and perfectly the process.

Table 1. The essence of each methodology (SixSigma, Lean Thinking and Theory of constraints (TOC) [13]

Program	Six Sigma	Lean thinking	Theory of constraints
Theory	Reduce variation	Remove waste	Manage constraints
Application guidelines	Define Measure Analyze Improve Control	Identify value Identify value stream Flow Pull Perfection	Identify constraint Exploit constraint Subordinate processes Elevate constraint Repeat cycle
Focus	Problem focused	Flow focused	Systems constraints

REFERENCES

[1] Goldratt, E. M., Cel I – doskonałość w produkcji, Mint Books, Warszawa 2007.

[2] Goldratt, E. M., Fox R., The Race, Croton-on-Hudson, The North River Press, Nowy Jork 1986.

[3] Bednarek M., Doskonalenie systemów zarządzania. Nowa droga do przedsiębiorstwa lean, Difin, Warszawa 2007.

[4] Dettmer W. H., Beyond Lean Manufacturing: Combining Lean and the Theory of Constraints for Higher Performance, http://www.tocca.com.au/uploaded/documents, 27.05.2009 r.

[5] Schragenheim E., Dettmer W. H., Manufacturing at Warp Speed: Optimizing Supply Chain Financial Performance, Boca Raton, FL: St. Lucie Press, 2000, http://www.amazon.com/Manufacturing-Warp-Speed-PerformanceConstraints/dp/1574442937, 27.05.2009 r.

[6] Goldratt, E. M., Cel II – to nie przypadek, Mint Books, Warszawa 2007.

[7] Goldratt, E. M., Łańcuch krytyczny, Werbel, Warszawa 2000.

[8] Critical Chain Buffer Management. Taming Uncertainty in Project Operations, www.pinnacle.com, 02.05.2008 r.

[9] Dettmer W. H., Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement, Milwaukee: ASQ Quality Press, 1997, www.goalsys.com, 04.03.2009 r.

[10] Dettmer W. H., Constraint Management, Quality America, Inc., 2000, www.goalsys.com, 04.03.2009 r.

[11] Schragenheim E., Dettmer W. H., Simplified Drum-Buffer-Rope A whole System Approach to High Velocity Manufacturing, Quality America, Inc., 2000, www.goalsys.com, 04.03.2009 r.

[12] Vitalo, R., Six Sigma and Kaizen Compared: Part 1 (Revised), Vital Enterprises, http://www.vitalentusa.com/learn/6-sigma_vs_kaizen_1.php, 26.05.2009 r.

[13] Nave D., How To Compare Six Sigma, Lean and the Theory of Constraints, http://www.lean.org/Community/Registered/ArticleDocuments/ASQStoryonQualitySigmaAndLean.pdf, 26.05.2009 r.

[14] Bednarek M., Stałe usprawnianie zarządzania jako podstawowe narzędzie poprawy pozycji konkurencyjnej przedsiębiorstw, Wyższa Szkoła Humanistyczno-Ekonomiczna, Łódź 2002.

[15] Grudzewski W., Hejduk I., Metody projektowania systemów zarządzania, Difin, Warszawa 2004.

[16] Grudzewski W., Hejduk I., Wpływ technologii na przedsiębiorstwo przyszłości, Difin, Warszawa 2000.

Climate Change in the Ecological Policy of Enterprises

Monika Wińska[1], Iwona Rybicka[2]

[1]Faculty of Mechanical Engineering, Lublin University of Technology, Lublin, 20-618, Poland (MSc. Eng.)
[2]Faculty of Mechanical Engineering, Lublin University of Technology, Lublin, 20-618, Poland (MSc. Eng.)

Abstract Climate change is nowadays one of the most urgent challenges facing humanity. Therefore, each company, considering its good reputation, devotes a lot of attention to introducing pro-ecological solutions. This is done both at the level of processes carried out in the company and at the staff level. Regardless of the industry, there is an improvement in the awareness not only of employers but also employees in the matter of jointly caring for the environment in which they live. A number of new technological solutions are being introduced and employees are trained to stimulate and develop pro-environmental behaviour. In addition, reports are prepared containing information on the current situation in the company regarding the implementation of ecological solutions. Hence, the environmental policy of companies, regardless of the company's industry, plays an extremely important role in improving the state of the environment. The article presents examples of solutions used by one of the leading logistics operators with a range not only local or European but also global.

Keywords environmental management, green technologies, teardrop trailer, CO_2 emission

JEL Q55, L99

1. Introduction

Although the significance of environmental aspects in company management has been growing in recent years, the significance and value attributed to this subject by people and organizations are still very different. In some organizations, responsibility for the environment consists in preparing for changes in legal regulations imposed by the government, while in others it is about taking account of the changing needs of customers. It may also address a number of other issues, such as cost efficiency, energy security, attractiveness of employers, or shareholder value. And sometimes it is a phenomenon driven by a sense of environmental awareness.

Views on activities carried out under environmental responsibility vary widely. When it comes to improving environmental performance, different areas of interest can be observed - while some organizations focus on supporting employee awareness and responsible behaviour on a daily basis, or on introducing technological innovations, others focus on setting policies and guidelines or creating space for new ideas and finding an innovative solution. The article presents pro-environmental solutions that have been introduced in the policy of one of the major logistics operators on the global market, which is the Deutsche Post DHL Group. As part of the DHL group's operations, most of the previously mentioned aspects played an important role in configuring and managing the environmental program. However, especially in recent years, the path of technological innovation is gaining more and more importance in the environmental protection agenda, leading to solutions such as its own StreetScooter - an electric vehicle for delivery of letters and packages that was created for the needs of the Deutsche Post DHL Group, an aerodynamic teardrop trailer for supply chain operations and DHL Cubicycle with downtown express delivery services.

Motivating factors and strategic justification for ecological innovations in the DHL Group, as well as the framework for supporting appropriate approaches and selected results will be discussed in more detail on the following pages.

2. The role of environmental management and innovation in the Deutsche Post DHL Group

The factors of responsible logistics in many cases correspond to those observed in other companies. For the Deutsche Post DHL Group, the initial motivating factor for its environmental management activities was responsibility towards society and the environment for limiting the negative impact of business operations. Since then, additional factors have been taken into account, including stricter legal requirements, growing customer requirements, and increasing investor and employee awareness, which underlines the need for commitment. However, greenhouse gas emissions have the largest share in the environmental footprint, so this issue has been recognized as the most important position in environmental policy programs in logistics companies.

Recognizing the need for change, DHL was the first globally operating logistics company to set a carbon efficiency target, striving to improve its carbon efficiency by

DOI: 10.26552/tac.C.2020.1.8

30% by 2020 compared to base year 2007. By the end of 2016, DHL had achieved a 30% low carbon goal well ahead of schedule.

Pursuant to these final arrangements, the GoGreen program was established in 2008 to increase the DHL Group's environmental performance. The program consists of five pillars presented and described in Figure 1.

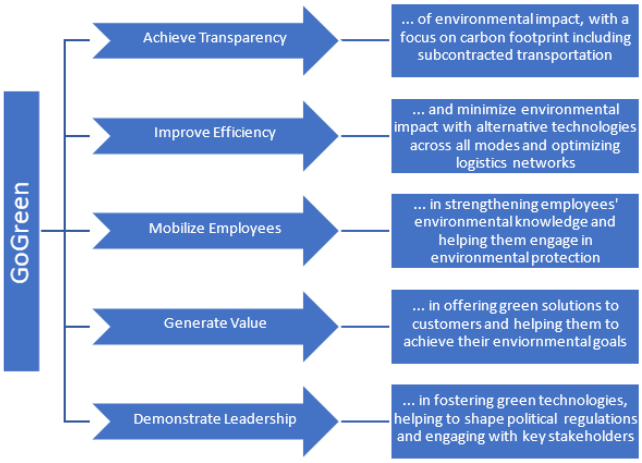

Figure 1. The five pillars of the GoGreen program implemented under the DHL Group Environmental Policy [1].

The implementation and development of innovative solutions in the field of "green" technologies finds their main application in the pillar of the "Improving performance" program. The mobilization of employees and increasing employees' awareness of the impact of their daily activities on the environment also plays a significant role in increasing productivity.

Activities such as driver training and "GoGreen office controls" have brought positive results in the Deutche Post DHL Group. Nevertheless, emission reduction due to technological innovations and implemented solutions brings a number of benefits that made this approach particularly applicable and successful in the organization:

• Green technologies are often seen as an attractive "premium" option compared to the traditional quo status. This increases the involvement of employees and managers in caring for the environment.

Example: electric vs conventional diesel vehicle

• Technological solutions offer the possibility of achieving a high level of carbon efficiency up to 50% and more. Without the right solutions, achieving the goals of the Paris Climate Agreement would be difficult to achieve.

Example: advanced biofuels for transport, LED lighting in buildings

• For organizations and employees who face huge challenges, technological solutions can help improve environmental impact.

Example: speed limiters and anti-idling systems, individual behaviour management.

The company's environmental and energy policy also plays a huge role in enterprise management. It is based on generally prevailing laws and regulations regarding environmental protection supplemented with additional corporate principles. These include an investment policy that requires all new investments to be more efficient in terms of carbon dioxide emissions than previous ones (each new investment proposal must include calculations indicating lower emissions). The second element of the company's environmental policy is the policy of ecological electricity. It boils down to the assumption that the primary source of electricity in the DHL Group is green energy, i.e. electricity obtained from renewable sources. The only exceptions allowed are the unavailability of appropriate resources to conduct this policy or the fact that their use would be commercially unprofitable. The DHL Group car fleets largely use liquid biofuels that do not negatively affect local food production in the countries where they are produced.

3. Solutions used by the DHL Group

The transport sector currently represents 14% of global carbon dioxide emissions. The DHL Supply Chain Group is committed to providing solutions to the challenges it faces every day. Innovative solutions developed as part of the GoGreen environment and climate protection program include measures to reduce emissions and improve low-carbon emissions. It also reduces the company's dependence on fossil fuel resources, protects against rising energy prices and ensures the company's long-term success. Regular reporting on environmental and climate protection measures and progress in achieving specific goals allows for immediate intervention in the event of deviations from the planned objectives.

There are many solutions that help enterprises develop ecological behaviour applied by the company or its employees. While some focus on raising employees' awareness and work on their responsible behaviour during their daily routines, or on launching better and better technological innovations, others focus their efforts on implementing pro-ecological policy and supporting new innovative ideas for improving the environment.

3.1. Mission 2050: Zero emission

In March 2017, the DHL group announced its mission that by 2050 all logistics-related emissions will be reduced to zero. The goal of this endeavour is to contribute to a significant reduction of global warming. At the Paris Climate Conference in 2015 (COP21), it was established to limit global warming to well below 2 degrees Celsius. This also appeared in the UN 2030 Agenda for Sustainable Development.

The Group is introducing solutions that could also become helpful to clients using DHL services in achieving their own environmental goals. The zero emission logistics mission concerns both the activities of the DHL Group itself and its subcontractors in the field of transport. It is supported by intermediate stages, which are to be achieved by 2025 under the aforementioned GoGreen program:

• Globally, it will increase the carbon efficiency of its own activities and those of its transport subcontractors by 50% compared to the 2007 baseline.

• At the local level, the Group aims to improve the lives of people right where they live and work using clean transport solutions. Deutsche Post DHL Group will operate 70% of its own first and last mile services with clean pick-up and delivery solutions e.g. by bike and electric vehicle.

• More than 50% of sales will incorporate Green Solutions, making customers' supply chains greener.

• The Group will train and certify 80% of its employees as GoGreen specialists by 2025, and actively involve them in its environmental and climate protection activities. The company also plans to join with partners to plant one million trees every year [6].

3.2. Tree-planting

Referring to the mission "Zero emissions", the DHL group has started the tree planting campaign since 2017. Forests have always been recognized as factories "converting" carbon dioxide into oxygen. CO2 capture from the air is one of the many ecosystem services they provide. Most trees used for afforestation were planted by DHL's partner organizations - recognized charities, NGOs and national forest authorities around the world - as they are most familiar with local conditions and habitats. In 2019, the result was about 3 million trees planted.

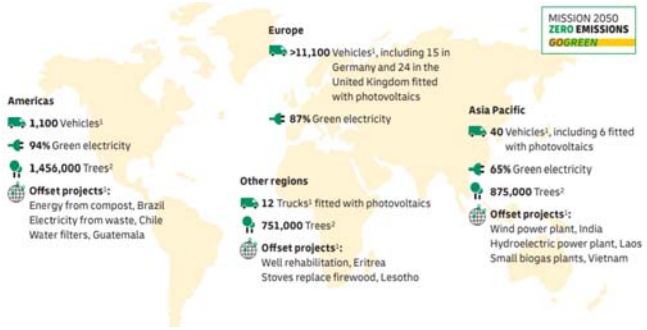

Figure 2. Environmental and climate protection measures in 2019 [7].

3.3. „Burn less" and „Burn clean" rules

In DHL's environmental policy, two basic principles can be observed in the efficiency approach: "burn less" and "burn clean". "Burn less" solutions focus on reducing energy and fuel consumption in the company's operations, while the "burn cleanly" task is to promote the use of alternative non-fossil energy and fuel sources to reduce harmful emissions to the environment.

The type of technology introduced in the company, based on two basic principles, is determined by a number of aspects, such as the area of application, geographical location or use. These conditions can be divided into four categories:

- expense;
- operational feasibility;
- environmental benefits;
- local or legal factors.

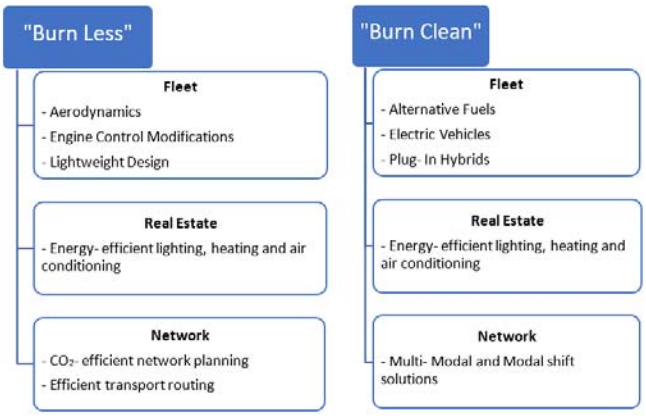

Figure 3. The DHL Group efficiency framework (based on [1])

3.4. Teardrop trailers

Teardrop trailers have been known for decades. Their aerodynamic shape reduces air resistance while driving, which results in lower fuel consumption. DHL Supply Chain Fleet Engineering UK together with the manufacturer Dob Bur created a design of such a semi-trailer dedicated specifically to the DHL group and introduced the first such vehicle on the market in 2009. The introduction of such a solution allowed to reduce fuel consumption by up to 10%.This solution was developed in subsequent years, taking into account the requirements set mainly by the logistics market in the UK.

In 2014, the DHL group expanded the range of use of teardrop trailers also to European countries. Currently, several trailers support deliveries in Germany, Benelux and France

3.5. StreetScooter

In 2013, DHL was looking for a more environmentally friendly method of collecting shipments from its own distribution centres and delivering them to recipients at the last stage of the delivery process. Because no manufacturer of delivery vehicles met DHL's expectations, the company decided to create its own car. However, due to the fact that DHL is a shipment supplier and not a car manufacturer, the company was not in the best position to start its own production of electric vehicles, all the more so because it requires excellent knowledge and technologically advanced production facilities. Therefore, in 2014, DHL invested in the StreetScooter electric startup vehicle designed from the very beginning exclusively for the commercial market.

Today, DHL uses 7,000 StreetScooter vehicles and 3,200 electric bikes, as well as 9,000 e-bikes and electric tricycles from other manufacturers (recently introduced to emerging markets, e.g. in Vietnam). Currently introduced mainly on European markets, StreetScooter is equipped with an electric drive system charged 100% with green energy, reducing CO2 production by approx. 20 thousand. tons per year. Almost every fifth vehicle in the DHL supply fleet is a zero-emission vehicle. The level of green energy use in the entire company is currently 63%.

DOI: 10.26552/tac.C.2020.1.8

According to the 2019 report, the DHL group uses 13,532 vehicles with alternative propulsion systems, of which 11,610 are electric vehicles. The diagram in Figure 4 shows the distribution of the use of vehicles with alternative propulsion systems by DHL [7].

In addition to the use of electric vehicles, the DHL group is also constantly improving conventional vehicles in line with the latest emission standards. Optimizing parcel collection and delivery routes is one of the steps to minimize the impact of company operations on air quality in urban areas. The changes that took place in the years 2015-2019 in the fleet of vehicles performing deliveries for the DHL group are presented in Figure 5 (in the next section of article).

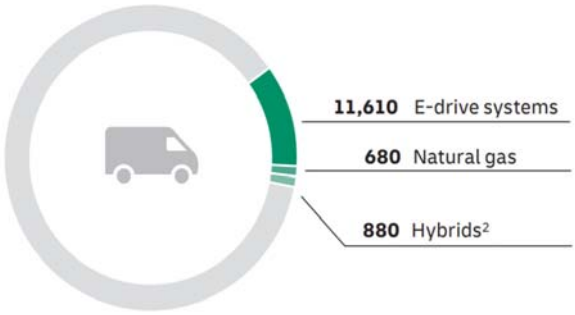

Figure 4. Alternative drive systems in 2019 (2- including 71 dual-fuel drive systems) [6]

3.6. Cubicylces

Cubicycle are special delivery bicycles, electrically assisted, which take a small 120x100x80 cm container. It can fit goods weighing up to 125 kg. The dimensions of the said cargo are calculated so that they fit the delivery trucks and can easily be loaded into larger containers, which DHL distributes its goods around the world.

The idea that a large delivery vehicle would reach a specific point in the city centre, where the packages were unloaded onto a cargo bike and delivered to the addressees nearby, was created in 2015. Then two pilot programs were launched - in German Frankfurt and in Utrecht in the Netherlands. Since then cubicycles operate in seven European cities. In total, DHL delivers bicycle shipments in 80 cities in 13 European countries.

In the case of instant deliveries, bicycles have many advantages: they freely drive around traffic jams and make twice as many stops per hour as delivery vans. The total cost of using our delivery bikes is more than twice the cost of vans. And the key thing is zero carbon, so they reduce our share of urban air pollution and help city authorities promote sustainable transport.

4. Analysis and forecasts regarding the environmental impact of the DHL group's operations

The DHL Group is constantly improving its conventionally vehicles to qualify for the latest emission standards. By optimizing supply routes, it indirectly minimizes the impact of your business on air quality in urban areas. The vast majority of vehicles providing transport services in the DHL group are vehicles belonging to the Euro 5 and Euro 6 standards or to the group completely emission-free (ZEV - Zero Emission Vehicle). The chart in Fig. 5 presents the share of individual emission standards among the DHL vehicle fleet in 2015-2019.

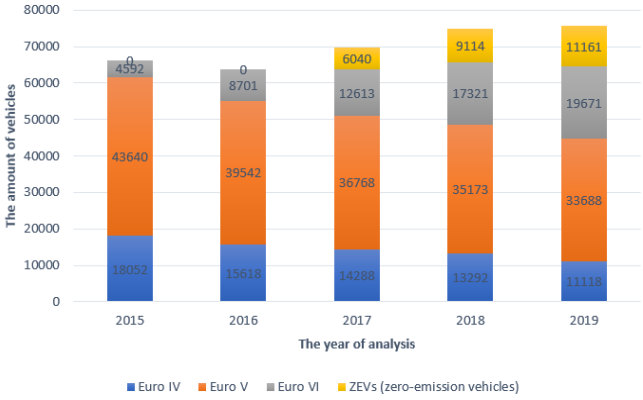

Figure 5. The amount of the DHL group's vehicles classified into individual emission standards [7].

The chart presents the changes observed in the years 2015-2019 in the development of DHL group's vehicles fleet. Since 2017 there appeared vehicles with „zero-emission" and every year this amount increases. At the same time, the share of vehicles with the lowest Euro 4 standard is decreasing. The Table 1 presents these changes in percentage:

Table 1. The percentage of vehicles in individual emission standards among all vehicles, in 2015-2019 [7]

	Year				
EURO Norm	**2015**	**2016**	**2017**	**2018**	**2019**
Euro IV	27,23%	24,46%	20,50%	17,75%	14,70%
Euro V	65,84%	61,92%	52,74%	46,96%	44,54%
Euro VI	6,93%	13,62%	18,09%	23,13%	26,01%
ZEVs	-	-	8,66%	12,17%	14,76%

Every year the amount of vehicles with the latest norm – Euro 6 and zero-emission vehicles increases. It can be observed also that the number of ZEVs increased twice in 2019 comparing to situation from the year when they were used first time in the DHL Group. Thus, a downward trend is observed in the share of vehicles with lower emission standards in all used vehicles.

When considering the environmental impact of a company, carbon dioxide emissions are a very important aspect to

consider. Each of the companies which is interested in limiting this issue conducts detailed annual reports, which are thoroughly analysed. Based on the results obtained and conclusions drawn, new solutions are introduced to minimize this factor.

Table 2 presents amount of CO2 emission in the years 2015-2019 and also amount of vehicles used in these years. Based on this data, the conventional annual CO2 emission rate per vehicle was calculated.

Table 2. The annual CO2 emission rate, counted per vehicle

Year	2015	2016	2017	2018	2019
CO_2 emission [tonnes]	27020000	26860000	28860000	29460000	28950000
Vehicles	66284	63861	69709	74900	75638
Rate of CO2 emission	407,64	420,60	414,01	393,32	382,74

Using the data contained in Tab. 2, the CO2 emission rate per vehicle was forecast for the next 6 years (until 2025).

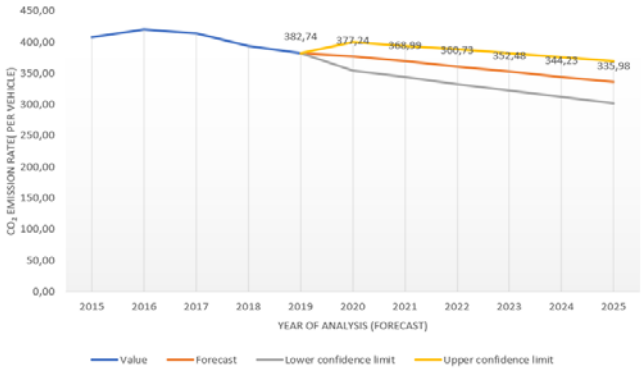

Figure 6. The forecast of the CO2 emission rate per vehicle in the years 2015-2019.

The chart at Figure 6 shows mentioned forecast and the decrease of the CO2 emission rate in the next years (2020-2025) what could be a proof for effects of ecological policy of the DHL Group. There wasn't considered that will be the significant increase of the vehicles amount and what will be the number of ZEVs. Forecast is based on historical data. The predicted value is the y value for a given x value. The known values are existing x and y values, and the new value is calculated by linear regression. The red line presents mentioned forecast. The orange lines are the chart of confidence limits for calculated forecast. Confidence interval is the range around each of the forecasted values, which according to the forecast should be 95% of future values (assuming normal distribution). The confidence interval can help to determine the accuracy of the forecast. A smaller range means greater certainty of the forecast for a specific point. The confidence interval at the chart 9 equals 95%.

5. Conclusions

At a time when so much is said about ecological disasters and about human impact on the environment, it is of great importance that the leading companies on the market, both large and small, use ecological solutions. It is understandable that if humanity wants to ensure that the Earth can be sealed for future generations, it must now work together to identify and reduce emissions. Enterprises join this mission by balancing their activities and ultimately moving to a circular economy.

The Transport and Logistics Sector, as an element of the global economy, plays a key role in terms of environmental impact, at least because of the means it uses when implementing the transport function. Hence, companies of global importance, among which the DHL group is discussed in the article, devote great attention to solutions that they introduce to the market. They focus on customer satisfaction, but above all they ensure that their activities have as little damage as possible to the environment. They introduce solutions that not only contribute to reducing the harmful effects of the company's activities, but also help their clients and subcontractors to pursue ecological policy in their own companies.

The analyses described above prove that the environmental policy pursued by the DHL group actually brings effects in terms of minimizing the harmful effects of their activities on the environment. Following the forecasts received, it can be safely stated that the dimension of this activity is noticeable and brings measurable effects. There was forecasted that rate of CO2 emission (per vehicle) will decrease even by 12,3% in the next 5 years. However, it was assumed that the situation would develop the same as in 2015-2019 (without taking into account radical changes that could affect the volume of this issue and significantly reduce it.

Using the knowledge of the people forming the DHL community, as well as many years of experience, the DHL group strives to run the enterprise by applying the principles of circular economy in order to eliminate waste and preserve the greater value of products. This is extremely important in the context of ensuring the common good, which is the Earth's resources, which are so much exploited should be subjected to even more protection than ever.

REFERENCES

[1] R. Altenburger, Innovation Management and Corporate Social Responsibility, Springer 2018.

[2] A. Sładkowski, Ecology in Transport: Problems and Solutions, Springer 2020.

[3] O. Seroka-Stolka, Green initiatives in environmental management of logistics companies, Transportation Research Procedia, vol. 16, pp. 483 – 489, 2016.

[4] D. T. Tran, W. K. Wong, M. Moslehpour, Q. L. H. Xuan, Speculating environmental sustainability strategy for logistics service providers based on DHL experiences. Journal of Management Information and Decision Sciences, vol. 22, no. 4, pp. 415-443, 2019.

[5] H. Vidová, D. Babčanová, K. Witkowski, S. Saniuk, LOGISTICS AND ITS ENVIRONMENTAL IMPACTS, Conference Paper of 7th International Scientific Conference "Business and Management 2012" May 10-11, Vilnius, pp. 1007-1014, 2012.

DOI: 10.26552/tac.C.2020.1.8

[6] Online Available: https://www.dhl.com/en.html

[7] Online Available: https://www.dpdhl.com/content/dam/dpdhl/en/media-center/responsibility/dpdhl-sustainability-report-2019.pdf

[8] Online Available: https://www.un.org/sustainabledevelopment/cop21/

TRANSPORT AND COMMUNICATIONS

Scientific journal intended to combine theory and practice in the field transport and communications and thus advancement of transport and communications sciences.

Each paper was reviewed by two reviewers. Authors hold responsibility for linguistic quality (language as well as grammar accuracy) of the article.

The Scope of Journal: Transport and postal policy, Public passenger transportation systems, Quality of transport and post services, Demand and supply in transport, post and telecommunications, Logistic systems, Road transport, Rail transport, Water transport, Air transport, The business environment in the SR, The cross-border cooperation.

Journal is excerpted in **Index Copernicus** database (ICV 2018 73.07).

Frequency of publishing: Twice per year.

Publishing language: English

Publisher: The Faculty of Operation and Economics of Transport and Communications, University of Žilina, Univerzitná 1, 010 26 Žilina, Slovakia

Printed: EDIS – Printing House of the University of Žilina, Univerzitná 1, 010 26 Žilina, Slovakia

IČO 00 397 563

Edition: 30 pc

Registered No: EV 4902/13

Tel: ++421/41/5133051

Email: tac@fpedas.uniza.sk

Web: http://tac.uniza.sk

May 2020

DOI: 10.26552/tac.J.2020.1

ISSN 1339-5130

ISSN 1339-5130

DOI: 10.26552/tac.J.2020.1