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ASSESSING THE ECONOMIC IMPACT OF USING ITSS (INTELLIGENT TRANSPORTATION SYSTEMS) ON GASOLINE CONSUMPTION IN IRAN (CASE STUDY OF KARAJ-CHALOUS AXIS)

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Abstract

The problems and challenges of the transportation business include environmental pollution, reduced amount and increased cost of energy resources, material and moral harms of increased accidents, surveillance, and management of suburban transportation, increased wasted time, and the quick expansion of transportation needs, particularly during rush hour in the metropolises worldwide today. Progress in public knowledge, better living standards, the increased value of time, and the introduction of novel sciences and technologies regarding this business have led to higher expectations. This phenomenon has become a serious threat from one point of view and a chance for profitable investment from the outlook of marketers and experts. In this respect, the ITS (intelligent transportation system) has been employed to tackle these problems. Hence, this study addressed reducing gasoline consumption using the ITS on Iran's Karaj-Chalous axis. The statistical population of the research includes vehicles moving during the eight busy days of September 2017 from 1 am to 24 pm on the Karaj-Chalous axis. Selective sampling was not performed. The results proved that the ITS decreased the travel time on the Karaj-Chalous axis and, therefore, the gasoline usage. The results confirmed that the ITS used in the eight days studied reduced 1096314 liters of fuel consumption in the Karaj-Chalous axis.

Keywords: Intelligent Transportation System, Traffic, Karaj-Chalous Axis

INTRODUCTION

Traffic is one of the problems of today's communities in metropolises. Heavy and challenging traffic in these cities is caused by the increased number of cars and the lack of adequate road expansions for vehicles to commute. The major issue of traffic congestion in metropolitan sites is primarily because of the structure or unsuitability of the city streets because of the sufficient capacity of existing automobiles. However, the truth is that other factors are involved, namely the traffic control tools and strategies, that affect the traffic situation. These factors, to their extent, can make the appropriate and fortunate physical conditions of traffic inconvenient or exacerbate the current traffic issues (Abolhassanpour, 2008). On another note, air pollution results from the released exhaust gases caused by the fossil fuels consumed in vehicles. The concentration and mixture of these pollutants depend on vehicles' velocity, acceleration, or standstill operation. Contaminations known to cause air pollution in cities include carbon monoxide (also toxic in low concentrations and can provoke sickness, headaches, and dizziness), nitrogen oxides (NOx), hydrocarbons, ozone, particulate matter, and suspended particles that include suspended dust particles (Ministry of Roads and Urban Development, 2016).

Overall, traffic is a prevalent problem for all classes, and improving the efficiency of the current transportation systems is the chief objective of the ITS applications worldwide. Congestion can be reduced by controlling the needs by enhancing the efficiency of the transportation grid by modifying the pattern of traversing by private car to other vehicles (Abolhassanpour, 2008).

One of the most basic infrastructures essential for expanding industries and the advanced level of social welfare of every country is smooth and secure conveyance (Akbari Motlagh and Salari, 2015). Furthermore, with the growth and blossoming of human societies, the requirements have shifted. As a result, the necessity to operate modern necessities and technologies in any domain is inescapable. Conveyance science is no exception in this respect and, in recent years, has presented and executed new technologies carrying the name intelligent transportation systems globally (Yousefzadeh Fard and Hossein Eskandani, 2010).

ITS is ascribed to systems using information, communications, and control technologies to govern transportation networks. The tools of this intelligent system, other than enhancing the execution of the transportation network, are also employed to contain wastage of time and save lives. These instruments, therefore, enhance the quality of life and the environment and make business more profitable. ITS tools save time and human lives, increase the quality of life and the environment, and improve the productivity of business activities (Safari, 2004). If ITS works suitably, it will raise people's trust in the transport grid, and by optimizing the system, it will deliver substantial economic savings for the people and the government yearly (Yousefzadeh Fard and Hossein Eskandani, 2010).

In this respect, the intelligent transportation system can play an essential part in lowering emissions and greenhouse gases and decreasing energy consumption. Further, it is now seen that the intelligent transportation system can be employed as a fourth principal factor in enhancing the operational efficiency of the conveyance system, and therefore, the general decline of greenhouse gas emissions (Barth et al., 2015).

Chalous Road, officially called Road 59, is among the critical access roads to northern Iran for the people of Tehran and Karaj. This axis begins from the city of Karaj in Alborz province and reaches the city of Chalous in Mazandaran. Statistics regarding the country's Highways and Road Transport Organization reveal that more than 25 million vehicles travel on the Karaj-Tehran axis each year. Of these, 5 million vehicles have to cross the Karaj-Chalous axis to reach the country's northern cities. Consequently, the infrastructure of this road does not satisfy the existing traffic. During holidays and travel days, heavy traffic and delay hours are what the passengers crossing this road suffer. This challenge has no answer but to make the route one-way.

Nevertheless, this resolution has driven thousands of problems for 56 villages along the road. Accordingly, it is required to deliver a solution for traffic control on this axis. One of these solutions is to employ intelligent transportation systems. Hence, this study addresses the impact of operating ITS on gasoline consumption on the Karaj-Chalous road. (Jaghoubi S., 2019; Jaghoubi S., 2021)

Theoretical bases of study

Since the industrial economy substituted the agricultural one, due to more investment in cities, people have moved from the rural population and texture to high-population cities and new colonies. On the other hand, the expanded automobile production and the restricted expansion of roads and fit infrastructure resulted in traffic congestion, decreased transport efficiency, more travel time, pollution, and undue consumption of fossil fuels. With the upheaval of urban traffic, the new leaders concluded that they should consider the new problem of metropolitan communities, the traffic, and outcomes. The chief goals include decreasing and managing traffic, smoothing the traffic, preserving the environment, lessening the travel time, managing and declining road accidents, and generally decreasing the adverse psychological, physical, social, and economic consequences of unexpected congestion on Society (Sharif Tehrani et al., 2017).

Traffic is an extensive and controversial issue that demands scientific and applicable plans and tactics, and solving it needs basic infrastructure.

Cities can ease the traffic load at crucial times with the support of the police and by improving the public transportation service fleet. However, to solve the traffic trouble, planning must be made in advance (Jabbari et al., 2011).

Nowadays, information technology to its size has also outweighed traffic management techniques. Today, traffic handling procedures using information technology appropriately use contemporary technologies to develop traffic and fulfill the necessities and desires of users. Information technology presents us with different methods to handle and lower traffic, including the fact that it is feasible to decrease urban traffic by building e-cities. Another answer is the concurrent usage of global positioning systems and the Internet, ITS, the expansion of e-commerce, etc., all of which are based on computers and information technology. Furthermore, another answer to the traffic problem in all metropolises worldwide is expanding intelligent transportation systems (Hassanpour et al., 2015).

ITSs using new technology (such as electronics, communications, and control systems) in an integrated way enhance the level of security, efficiency, and lower price of transportation can be generalized to various modes of conveyance (by road, rail, air, and sea). These systems form a dynamic association between drivers, vehicles, and transport infrastructure (roads, railways, etc.) to trade information, leading to better management procedures and more efficient use of available resources. This coordination is better demonstrated in communication between different types of transport and control centers and public users (Amini Tusi et al., 2012).

The advantages of using ITS: increased production capacity of infrastructure, automating intelligence operations (statistics, information, processing, the transmission of information, etc.), improved level of safety and efficiency of conveyance systems by using new electronic technologies, reducing the demand for the continuous and concurrent presence of workforce at operational levels, removing the restrictions of using fixed and low-efficiency systems, eliminating human error in the provision, transmission, and processing of information through the use of intelligent transportation systems (Momivand et al., 2019).

Drawbacks of using ITSs

Nowadays, the operation of intelligent transportation systems has drawbacks, troubles, and limitations for some reasons. Overall, the latest technologies, such as information technology, and ITSs are employed to coordinate, quicken the information transfer, reduce costs, and similar applications. At the same time, these achievements depend on the current transportation structure of each country. Using an intelligent transportation system in different countries has distinct functions and outcomes. That is why the major projects defined in the creation of ITSs in the country encounter many restrictions, including (Qadbik and Ehsanifar, 2019):

- Absence of existence or adherence with existing laws for using new equipment
- Lack of coordination between different agencies in using intelligent transport systems,
- The high initial price of purchasing and using these systems,
- Lack of adequate knowledge in countries to set up and use intelligent transportation systems and the like,
- High prices of building and establishment of infrastructure (particularly telecommunication infrastructure)
- Issues of some governments in defining policies for the use of satellite networks

Research Methods

This research is descriptive. "Descriptive research aims to answer questions by analyzing the associations between variables. In this way, the exact content of messages is described systematically and quantitatively." The chief idea of content analysis is to put the elements of the text (words, sentences, paragraphs, and the like) according to the units chosen in several predefined categories. This approach can be considered a method of transforming qualitative data into quantitative ones. Content analysis is a wonderful method to answer questions regarding the content of a message. To conduct the study, preliminary and theoretical studies were initially done to determine the variables being measured. Using the presented theories, the theoretical framework employed was extracted. Then, the principal element was operationally defined. Next, the quantities related to each variable are determined using the scientific relations of physics and chemistry.

Research Hypotheses

Hypothesis 1: Output and entry vehicles to the investigation area (Karaj-Chalous) from villages and sub-villages are neglected

Hypothesis 2: Fuel consumption is calculated based on travel time, not engine speed.

Hypothesis 3: The stopping and moving of vehicles along the studied route (Karaj-Chalous) for any reason, including tourism, accidents, drivers driving, etc., are ignored.

Hypothesis 4: Road structure and other factors influencing the speed of vehicles along the same path are factored in (such as slope, tunnel, road width, traffic signs, light, etc.)

Hypothesis 5: Cars are considered to be the same type.

Hypothesis 6: Natural catastrophes such as snow, rain, landslides, floods, etc., have been neglected.

Hypothesis 7: The chemical formula of gasoline is octane C8H18.

Considering that the statistical population refers to the whole group of people, occurrences, or things that the researcher wants to study and are the variables that are examined, the statistical population of this research includes vehicles that traveled on the busy days of the tenth, twelfth, thirteenth, fourteenth, fifteenth, seventeenth, twenty-fourth and thirty-first of September 2019 on Karaj to Chalous axis. No other specific sampling has been done in this respect.

The mechanism for measuring the effects of using ITSs on road traffic control and greenhouse gas emissions

Step 1: Initially, the amount of carbon dioxide emissions in the research area (time and location) before using information technology (current situation) was determined. Having information about travel time and the number of cars in the study area, the weight of carbon dioxide produced by a vehicle was calculated using the following equation.

$w\ co_2 = \bar{t}_r . \overline{w_r\ co}_2$

Where $\overline{w_r\ co}$ is the average weight of carbon dioxide produced by a car in kilograms per hour. Accordingly, considering the number of samples (N), the total weight of carbon dioxide ejected in the current situation (before the application of information technology) in the research area (temporal and spatial) is calculated using the following equation.

$$w_t co_2 = \sum_{n=1}^{N} n_{rc}\, \overline{t_{rn}}\, \overline{w_{co_2}}$$

Where n_{rc} represents the current number of cars on the road.

Step 2: To calculate the amount of carbon dioxide emissions in case information technology is used (the situation desired by the researcher) in the study area (time and place), we do as the following.

Since the speed of any car on the road depends on the following factors:

N_{rc}: number of cars on the road

Vz: Speed of other cars

IN: Number of vehicles entering the road

EX: Off-road vehicles

C_k: Type of vehicles

R_m: Road construction (slopes, turns, and other physical factors of the road)

S: Stop other vehicles (rotation, breakdown, service, etc.)

H_a: Accidents

W: Weather conditions

C_c: Driving culture

ND: Natural disasters (mountain falls, tunnels, landslides, floods, etc.)

L: The amount of road lighting

It can be said that $\bar{v}_r$ (average vehicle speed along the route) is a function of:

$V_r = f\,(N_{rc}, V_z, IN, EX, C_k, R_m, S, H_a, W, C_c, ND, L)$

In case, according to the research hypotheses, other factors are fixed, and only the number of cars on the road varies, we have:

$V_r = f\,(N)$

Now, to determine the association between the number and speed of vehicles in the study area, we estimate the following pattern:

$$\bar{v}_r = a - b n_{rc}$$

Where $\bar{v}_r$ is the average speed of the cars $\bar{v}_r = \frac{x}{\bar{t}}$, x being the length of the road, 160000 m (160 km) and $\bar{t}$ is the average travel time based on the real data available for the studied extent. a, b are next estimated using the *Eviews* software.

In the above relation, n_{rc} represents the actual number of vehicles (actual data available in the study area).

Road efficiency is at maximum when cars can cross the road at the highest speed. To this end, using the relation $v''_r=\frac{x}{t''_r}$, the average speed of each car is calculated. Then, using the relation $v''_r=a-bn''_{rc}$, the value of the desired optimal vehicle at which time the trip reaches the desired range is calculated. Then, the total weight of carbon dioxide produced in the study area is calculated after using information technology (controlling the number of vehicles using ITSs).

$$Wt\text{'co2} = w'_t co_2 \sum_{n=1}^{N} n''_{rc}\overline{t'_r}\overline{wco_2}$$

Where $\overline{t''_r}$ is the average time of vehicles in the study area (Karaj-Chalous) after using information technology in terms of hours.

N''_{rc} is the optimal number of vehicles in the study area (Karaj-Chalous) after using information technology.

$W_t\text{'}co_2$ is the total weight of carbon dioxide produced in the study area (time and place) after applying information technology.

So it can be written:

$W'_t co_2 = N\, n''_{rc}\overline{t'_r}\overline{wco_2}$

Third stage: The difference between carbon dioxide emissions obtained from the first and second stages is calculated.

$$\Delta w_t co_2 = \left(\overline{wco_2}\sum_{n=1}^{N} n_{rcn}\overline{t_r}\right) - Nn''_{rc}\overline{t'_r}\overline{wco_2}$$

$$=> \Delta w_t co_2 = \overline{wco_2}[\left(\sum_{n=1}^{N} c_{rn}\overline{t_n}\right) - Nc'_r\overline{t'_r}]$$

Where $\Delta w_t co_2$ represents the difference in the total weight of carbon dioxide produced before and after the use of information technology

To perform research calculations, Excel statistical software and Eviews10 econometric are used.

Results

In this research, by mixing and using the information on the number and traffic per day, the average travel time per hour was calculated from the average travel time set per 5 minutes for one hour. Given the average travel time per hour, we calculate the average speed in meters per second and kilometers per hour using $\frac{x}{t}$. At this stage, according to the research assumptions, the fuel consumption of each car was considered 6 liters per hour. The fuel consumption of each car was calculated since gasoline can be chemically considered as C8H18 octane with a molecular weight of octane of 114 grams per mole.

C8H18 = 8 (12) +18 (1) = 114

The molecular weight of carbon dioxide is 44 grams per mole.

CO_2=1(12) + 2(16) =44

The molecular weight of water is 18 grams per mole.

H_2O= 2(1) + 16 =18

On the other hand, the octane combustion reaction equation is

$2\ C_8H_{18} + 25O_2 \rightarrow 16\ CO_2 + 18\ H_2O$ + Energy

Therefore, the mass of carbon dioxide (CO_2) released per mole of octane burned is 352 grams:

352 $g_r=\frac{16\times44}{2}$

The mass of water (H_2O) released per mole of octane burned is 162 grams:

162$g_r=\frac{18[2(1)+16]}{2}$

Also, the ratio of carbon dioxide emissions due to gasoline-burning is 3.0877:

3/0877$=\frac{352}{114}$

Moreover, the ratio of water production due to burning gasoline is 1.421:

1/421$=\frac{162}{114}$

Furthermore, the ratio of water production due to burning gasoline is 1.421:

1/421$=\frac{162}{114}$

Considering that each liter of gasoline is 0.74 kg, having the ratio of carbon dioxide emissions due to burning gasoline, which is 3.0877, we conclude that burning one gram of gasoline produces 3.09 grams of CO_2 and 1.42 grams of water.

$$\frac{1gr_{gasoline}}{740} = \frac{3.09gr_{Co_2}}{x}$$

X= 3.09×740 X=2286.6 gr

Hence, it can be stated that one liter of gasoline after combustion produces 2.23 kg of CO_2. Hence, having the amount of fuel consumption, the carbon dioxide produced in kilograms for each car is calculated. The amount of gasoline and carbon dioxide produced for each car and the number of cars, gasoline consumed, and carbon dioxide produced per hour is calculated by multiplying the two amounts mentioned per hour. Then, by summing the amount of gasoline consumed and carbon dioxide produced per hour, the amount of gasoline consumed and carbon dioxide produced in a day and night is calculated. Then, by summing the gasoline consumed and the carbon dioxide produced per day, the total amount of gasoline consumed and carbon dioxide produced at the time and place studied in the current situation is calculated: 4403943 liters of gasoline 10129069 kg of carbon dioxide (Table (1)).

Table 1.

	Studied days of the month	Total sum of the gasoline consumed per day	Total CO_2 produced per day in the current situation	Total number of vehicles during the study day
1	10th	356910	820892	16798
2	12th	32768	995367	21021
3	13th	719972	1655937	26340
4	14th	779838	1793628	24227
5	15th	684424	1574175	25049
6	17th	449686	1034277	14095
7	24th	488829	1124308	21185
8	31st	491516	1130486	20907
	Total sum	4403943	10129069	169622

On another note, having the values of travel time and the total number of vehicles, the average speed per trip is determined for each day (24 hours) for 5 to 7 travel groups are extracted.

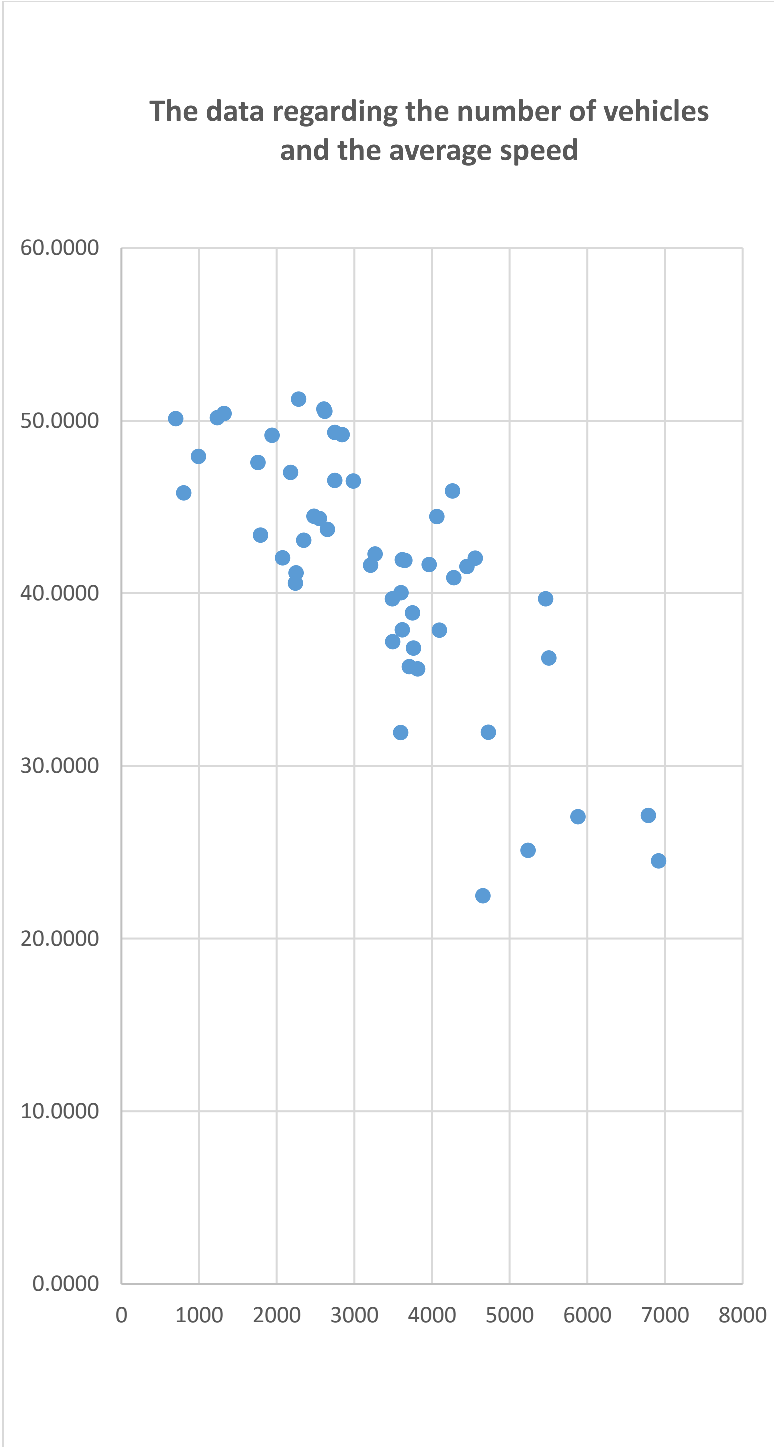
Here, to evaluate the extracted information model, we consider Table (2) as the main data source (statistical population) of the study.

Table 2.

Total number of vehicles on the road	Average speed of the vehicles on the road
2180	47.0035
1323	50.4226
2609	50.6839
2748	49.3205
3618	41.9538
2242	40.6045
2078	42.0691
1238	50.1800
700	5013332
2284	51.2521
2619	50.5437

4265	45.9386
4450	41.5671
5464	39.6831
4559	42.0395
4062	44.4630
3709	35.7534
5236	25.1209
5504	36.2709
3270	42.2806
3209	41.6419
3818	35.6402
6921	24.5096
6788	27.1412
3419	39.6952
3650	41.6419
3818	35.6402
6921	24.5096
6788	27.1412
3491	39.6952
3650	41.9210
3965	41.6699
4725	31.9661
5879	27.0698
4280	40.9141
2550	44.3350
993	47.9452
803	45.8181
1794	43.3797
2251	41.1843
4657	22.4849
3597	31.9439
2482	44.4809
1759	47.8506

2844	49.1916
3601	40.0500
4098	37.8746
3749	38.8774
2652	43.7196
2349	43.0848
1943	49.1589
2986	46.5153
3763	36.8404
3496	37.2156
3620	37.9029
2750	46.5464



It is essential to express these data before analyzing the statistical data to comprehend better the nature of the statistical population studied in this research and become more acquainted with the variables. The statistical description of data is also an effort towards recognizing the pattern governing them and a basis for explaining the connections between variables used here. Table (3) displays the descriptive statistics of the study variables. Descriptive statistics of research variables including mean, median, variance, standard deviation, minimum, and maximum are listed.

In the descriptive statistics table, mean, mean, maximum, minimum, standard deviation, skewness, and elongation of the research variables are displayed from top to bottom, respectively. In this study, 51 data (observations) have been employed to examine the research model hypothesis.

Table 3. Statistical description of the research variables

	V	N
Mean	41.28594	3325.922
Median	41.95380	3491.000
Maximum	51.25210	6921.000
Minimum	22.48490	700.0000
Std. Dev.	7.205903	1416.556
Skewness	-0.865954	0.416578
Kurtosis	3.296514	3.051186
Observations	51	51

Matrix of correlation coefficients of model variables (detection of alignment test of independent variables)

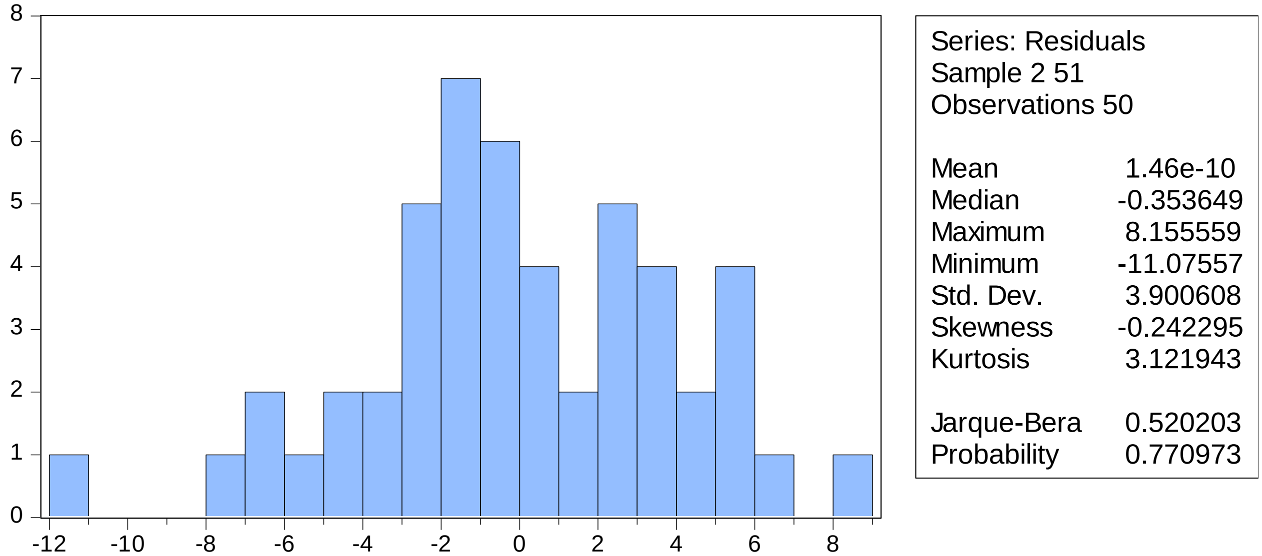
This matrix is one of the simple criteria for identifying the lineage using correlation coefficients between explanatory variables. If the correlation coefficients between the explanatory variables are relatively large, the correlation is relatively strong. Otherwise, there is no alignment.

Table 4. Matrix of correlation coefficients of model variables

	V	N
V	1	-0.7820410026362861
N	-0.7820410026362861	1

According to Table 4, there is no alignment between the model variables.

Results of normality of disturbance component distribution (Jarque-Bera Test)



The null and alternative hypotheses of this test:

Normal distribution of perturbation components H_0:
H_1: Abnormal distribution of disturbance components

Based on the results, the probability of the Jarque-Bera test statistics in the model is higher than 5%. Hence, the null hypothesis that the distribution of perturbation components is normal in this model is not rejected. In the research model, the total number of vehicles along the route (n) is entered as the main independent variable, and the average variable of vehicle speed along the route (V) is entered as a dependent variable.

Results of Distinguishing Distribution Component Independence (Self-Correlation Test) of the Model

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.672820	Prob. F(2,45)	0.5153
Obs*R-squared	1.451743	Prob. Chi-Square(2)	0.4839

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 09/23/21 Time: 21:41
Sample: 2 51
Included observations: 50
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.710952	2.221825	-0.319985	0.7505
N	0.000211	0.000565	0.373358	0.7106

AR(1)	-0.065383	0.495851	-0.131860	0.8957
RESID(-1)	0.161371	0.507684	0.317857	0.7521
RESID(-2)	-0.126326	0.292419	-0.432004	0.6678

R-squared	0.029035	Mean dependent var	1.46E-10
Adjusted R-squared	-0.057273	S.D. dependent var	3.900608
S.E. of regression	4.010753	Akaike info criterion	5.710475
Sum squared resid	723.8763	Schwarz criterion	5.901677
Log-likelihood	-137.7619	Hannan-Quinn criter.	5.783286
F-statistic	0.336410	Durbin-Watson stat	1.984240
Prob(F-statistic)	0.851980		

The null and alternative hypotheses of this test:

Independence of distribution of disturbance components (No autocorrelation) H_0:

H_1: Dependence of distribution of disturbance components (Autocorrelation)

Based on the results achieved from the LM test, the probability of F-test statistics in the model is higher than 5%. Hence, in this model, the null hypothesis representing the independence of the distribution of perturbation components is not denied, and there is no problem of correlation between perturbation components with more than one interrupt.

Results of detecting equality of variances between distribution components (heterogeneity variance test) of the Model

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.739073	Prob. F(1,48)	0.1935
Obs*R-squared	1.748196	Prob. Chi-Square(1)	0.1861
Scaled explained SS	1.638889	Prob. Chi-Square(1)	0.2005

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 09/23/21 Time: 21:50
Sample: 2 51
Included observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.244452	7.950437	0.659643	0.5126
N	0.002886	0.002189	1.318739	0.1935

R-squared	0.034964	Mean dependent var	14.91045
Adjusted R-squared	0.014859	S.D. dependent var	21.94040
S.E. of regression	21.77678	Akaike info criterion	9.038744
Sum squared resid	22762.95	Schwarz criterion	9.115225
Log-likelihood	-223.9686	Hannan-Quinn criter.	9.067868
F-statistic	1.739073	Durbin-Watson stat	2.098159
Prob(F-statistic)	0.193514		

The null and alternative hypotheses of this test:

H_0: Absence of heterogeneity variance

H_1: Presence of heterogeneity variance

According to the obtained results, the model's probability of F test statistics is higher than 5%. Therefore, in this model, the null hypothesis of the absence of heterogeneity variance is not ruled out. Hence, there is no problem of variance of inequality between the disruption components.

Results of specification error test (cryptographic reset) of the model

The null and alternative hypotheses of this test:

H_0: Absence of specification error

H_1: Presence of specification error

According to the obtained results, the model's probability of F and t test statistics is higher than 5%. Hence, in this model, the null hypothesis indicating no specification error is not rejected. Therefore, there is no problem with specifying errors in the model.

Ramsey RESET Test
Equation: FINALEQ01
Specification: V C N AR(1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.234781	46	0.8154
F-statistic	0.055122	(1, 46)	0.8154
Likelihood ratio	0.059880	1	0.8067

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.892297	1	0.892297
Restricted SSR	745.5224	47	15.86218
Unrestricted SSR	744.6301	46	16.18761
Unrestricted SSR	744.6301	46	16.18761

LR test summary:

	Value	df
Restricted LogL	-138.4985	47
Unrestricted LogL	-138.4685	46

Unrestricted Test Equation:
Dependent Variable: V
Method: Least Squares
Date: 09/23/21 Time: 22:05
Sample: 2 51
Included observations: 50
Convergence achieved after 10 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	50.69162	20.85924	2.430176	0.0191
N	-0.003585	0.002491	-1.439406	0.1568
FITTED^2	0.001458	0.007271	0.200555	0.8419
AR(1)	0.472743	0.254413	1.858170	0.0696

R-squared	0.709459	Mean dependent var	41.17159
Adjusted R-squared	0.690510	S.D. dependent var	7.232166

S.E. of regression	4.023383	Akaike info criterion	5.698742
Sum squared resid	744.6301	Schwarz criterion	5.851704
Log-likelihood	-138.4685	Hannan-Quinn criter.	5.756990
F-statistic	37.44174	Durbin-Watson stat	1.860647
Prob(F-statistic)	0.000000		
Inverted AR Roots	.47		

Final results of research model evaluation

Ramsey RESET Test
Equation: FINALEQ01
Specification: V C N AR(1)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.234781	46	0.8154
F-statistic	0.055122	(1, 46)	0.8154
Likelihood ratio	0.059880	1	0.8067

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.892297	1	0.892297
Restricted SSR	745.5224	47	15.86218
Unrestricted SSR	744.6301	46	16.18761
Unrestricted SSR	744.6301	46	16.18761

LR test summary:

	Value	df
Restricted LogL	-138.4985	47

Unrestricted LogL	-138.4685	46

Unrestricted Test Equation:
Dependent Variable: V
Method: Least Squares
Date: 09/23/21 Time: 22:05
Sample: 2 51
Included observations: 50
Convergence achieved after 10 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	50.69162	20.85924	2.430176	0.0191
N	-0.003585	0.002491	-1.439406	0.1568
FITTED^2	0.001458	0.007271	0.200555	0.8419
AR(1)	0.472743	0.254413	1.858170	0.0696

R-squared	0.709459	Mean dependent var	41.17159
Adjusted R-squared	0.690510	S.D. dependent var	7.232166
S.E. of regression	4.023383	Akaike info criterion	5.698742
Sum squared resid	744.6301	Schwarz criterion	5.851704
Log-likelihood	-138.4685	Hannan-Quinn criter.	5.756990
F-statistic	37.44174	Durbin-Watson stat	1.860647
Prob(F-statistic)	0.000000		

Inverted AR Roots	.47

V= 62.88127-0.004082N

Model hypothesis test result

One of the hypotheses of regression is the independence of the disruption components. Regression cannot be employed in case the hypothesis of the independence of the disruption elements is denied, and the disruption components correlate with each other. The Durbin-Watson test is used to test the independence of disruption components from one another. If the value of this statistic is near 2, the hypothesis of correlation between the disturbance components is rejected, and regression can be employed. Based on the table above, the value of the Durbin-Watson test statistic is 1.83, meaning that the disruption components are independent of each other, and there is no correlation between them. In other words, the hypothesis of correlation between disruption components is rejected, and regression can be employed.

After examining the regression hypotheses and confirming that they are met, the outcomes of fitting the mentioned regression equation are listed in the table. The value of the F statistic (57.28673) furthermore demonstrates the significance of the whole regression model. As suggested in the lower part of the table, the values of the determination coefficient and the adjusted coefficient of determination of the model are 70.91% and 69.67%, respectively. Therefore, in this regression equation, the variable of the total number of vehicles along the route accounts for 69.67% of the average changes in the vehicle speed across the route.

According to the above table, the significance level of the variable of the total number of vehicles along the route (n) (0.000) is less than 5%. Furthermore, the absolute value of the computational t-statistic of this variable (7.808823) is greater than the t-statistic acquired from the table with the same degree of freedom (1.96). This result reveals the significance of the variable coefficient of n at a 95% confidence level. According to the results, n has a negative and significant impact on the average speed of vehicles along the route in the first model. Increased n will decrease the average speed of vehicles along the route by 0.004082 units.

Total gasoline consumption and carbon dioxide production were calculated from the model after using information technology and the difference between the two modes:

V = 62.88127-0.004082N

When we plan to increase the travel time to 3.25 hours (3:15), we have for the average speed:

V= $\frac{160km}{3.25}$ → v=49.23 → 49.23=62.88127-0.004082N

N=3344

Accordingly, the entry of cars on the route for this period should be limited to 3344 units. If we consider each trip to take 3.25 hours, for 24 hours, 7,385 trips can be determined. Accordingly, if we consider seven trips per 24 hours, the total number of vehicles traveling the route in 3.25 hours by realizing the demand side will be 23,408 vehicles per day. This number will cover the current demand, even at peak travel demand.

$$Total\ time\ of\ trips\ in\ the\ studied\ location\ and\ time = total\ number\ of\ cars \times 3.25 = 169622 \times 3.25 = 551271.5\ hours$$

$$Total\ gasoline\ consumed\ in\ the\ studied\ location\ and\ time = total\ time \times 6 = 551271.5 \times 6 = 3307629\ l$$

$$Total\ CO_2\ Produced = total\ gasoline\ consumed \times 2.3 = 3307629 \times 2.3 = 7607546.7\ Kg$$

$$The\ difference\ in\ produced\ CO_2 = 10129069 - 7607546.7 = 2521522.3\ Kg$$

$$The\ difference\ in\ consumed\ gasoline = 4403943 - 3307629 = 1096314\ l$$

CONCLUSION

This study aimed to assess the economic outcomes of using ITSs on gasoline consumption in Iran (Case study of Karaj-Chalous route). Results indicated that the ITS reduced trip time on the Karaj-Chalous axis and, therefore, the gasoline consumption. Also, the results proved that the use of the ITS in the eight days studied decreased 1096314 liters of fuel consumption in the Karaj-Chalous axis. In this respect, it is claimed that the ITS can play an essential part in decreasing fossil fuel consumption plus enhancing road safety, lessening traffic congestion, and diminishing trip time. Therefore, it is proposed that an electronic system be created to manage travel demand that can control the time and number of vehicles entering the research area.

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