September 2025
Volume 1
Issue 3
DOI: 10.48308/IJCE.2025.241184.1012

Interdisciplinary Journal of Civil Engineering
Shahid Beheshti University

Values, Beliefs, and Norms in Modal Shift: The Role of Environmental Attitudes Under Demand Management Policies

Authors:

Alireza Mahpour[1, *], Parsa Zamani[1]

Abstract

This study examines how individuals' values, beliefs, and norms influence their responses to demand management policies targeting private vehicle use. Specifically, it investigates the impact of these latent variables on shifts in travel mode choice from private cars to public transit under a zonal pricing policy. A comprehensive survey was administered to 500 residents of Tehran's "air pollution control zone". Findings indicate that individuals with stronger environmental concerns and biospheric values were more likely to switch to public transit following the implementation of zonal pricing, whereas those with more pronounced hedonic values continued to rely on private vehicles both before and after the policy. Socioeconomic characteristics were also found to be significant. Individuals holding either a high school diploma or a master's degree were more inclined to use public transit after providing the scenarios. Trip purpose influenced travel behavior, with those traveling for personal errands or shopping more likely to use private vehicles regardless of the policy. Overall, the results suggest that zonal pricing, as a demand management strategy during periods of environmental concern, can be an effective tool for reducing private vehicle use, particularly when accounting for the interplay between environmental values, socioeconomic factors, and travel purposes.

Keywords: Environmental Concerns, Modal Shift, Transportation Demand Management, Tehran, Value-Belief-Norm

1. Faculty of Civil, Water, and Environmental Engineering, Shahid Beheshti University, Tehran 1983969411, Iran

*Corresponding Author: a_mahpour@sbu.ac.ir

1. Introduction

Rapid urban development has intensified challenges in transporting people and goods, with growing complexities in meeting mobility needs. Urban expansion has increased travel demand, often outpacing the capacity of existing transportation infrastructure. In recent decades, community livability has declined and economic growth has been hindered due to the uncontrolled rise in motorized vehicle use, leading to traffic congestion, environmental degradation, and other associated threats (De Vos, 2016).

Transportation demand management (TDM) has emerged as a key strategy to enhance the efficiency of urban transport systems by discouraging unnecessary private vehicle use and promoting healthier, more efficient, and environmentally sustainable alternatives, such as public transit and non-motorized modes (Mahpour and Saeedi Shahrivar, 2022). Within TDM, pricing policies can target specific areas, facilities, network links, or employ mixed approaches (Lindsey, 2003). Evidence suggests that measures such as improved traffic conditions, enhanced environmental quality, and better public transport performance can increase public acceptance of congestion pricing, particularly when implemented transparently (Ahadi et al., 2018; Glavic et al., 2017; Cipriani et al., 2018).

Improving environmental quality is directly related to shifts in public attitudes and behaviors toward sustainability. Greater engagement with environmental issues can foster the adoption of cleaner, more sustainable transport modes and reduce reliance on private vehicles (Gkargkavouzi et al., 2019). Previous studies indicate that individuals with stronger environmental values view the damage caused by vehicle use as a moral concern and are more willing to support policies aimed at reducing car dependence (Jakovcevic and Steg, 2013). These moral considerations, which can encourage lower vehicle use and promote better environmental conditions, are referred to as environmentally friendly behaviors (Miller et al., 2014).

In the present study, the variables of the value-belief-norm (VBN) theory, which are based on environmentally friendly activities, values, and beliefs (Stern, 2000), were applied as latent variables to assess individuals' environmental attitudes toward reducing private vehicle use. The present study also incorporates socioeconomic characteristics and travel-related factors. This approach was applied in a case study evaluating the effectiveness of a zonal pricing policy as a transportation demand management measure in Tehran, Iran.

2. Literature Review

The most recent report issued by the International Energy Agency (IEA) indicated that the level of carbon dioxide pollutant emitted by combusting fuel reached 31.86 Gtons in 2018, around 27% of which was related to the transportation sector (Akbari et al., 2020). Grelier and Engineer introduced motorized vehicles as the origin for 72% of the surface pollution caused by the transportation sector in Europe during 2015 (Grelier and Engineer, 2018). Tehran is no exception: a report released in 2019 by the Tehran Air Quality Control company revealed that

only 29 days (8%) were considered “clean” in the metropolis during that year (Mahpour et al., 2024).

The share of mobile and stationary sources in pollutant creation, and consequently air pollution, was 83% and 17%, respectively. Since personal vehicles produce the central part of the pollutants caused by the transportation sector, mode choice for traveling can be considered environmentally friendly behavior due to its potential effect on the environment, the health and the quality of life of individuals (Van der Werff and Steg, 2016). Thus, the level of valuing the environment by individuals, and their willingness to enhance environmental conditions, can be assessed in the structures called environmentally friendly attitudes.

In the present study, environmentally friendly attitudes and behaviors were examined by applying VBN theory based on the theory's criteria to evaluate individuals' environmental attitudes. In addition, value orientations, including biospheric, altruistic, egoistic, and hedonic groups, were proposed in the previous research as the first part of the chain of the theory (Kiatkawsin and Han, 2017; Nordfjærn and Fallah Z, 2017; Hiratsuka et al., 2018; Unal et al., 2019). The individuals having deep concerns about environmental conditions, such as air pollution and global warming, are those with a stronger belief in biospheric value. Further, those who are deeply concerned about the needs and social welfare of other individuals believe in altruistic values more strongly than others. Both of the values mentioned above are positively related to the environmental condition (Annika and Garvill, 2003; Cleveland et al., 2005).

Along with the aforementioned values, other values are available with a stronger belief in maintaining personal benefits, the nature of which implies personal ethics and hedonism (Unal et al., 2019). These values are known as hedonic and egoistic and are negatively related to environmental ones (Steg et al., 2014b). In the structure of VBN theory, there is a branch of beliefs representing individuals' environmental concerns, which is named the new environmental paradigm (NEP) (Dunlap et al., 2000). The NEP indicates any relationship between humans and the environment in the form of a worldview on the issues. Further, it demonstrates how humans consider themselves as a part of the environment or believe in their dominance over the environment (e.g. Mahpour et al., 2022a; Mahpour et al., 2022b;Unal et al., 2019). The NEP obtained by value orientations predicts another branch of environmental beliefs, known as the awareness of consequences (AC) (Kiatkawsin and Han, 2017). AC refers to individuals' awareness regarding the effect of their behavior on the environment. Researchers found that the AC appeared for the environment through travel mode choice. Feeling the responsibility for the consequences of transportation choices led to a moral commitment. This, in turn, influenced people to be more accepting of transportation plans that included a car-use toll approach (de Groot and Steg, 2009).

Based on the results of the studies in the field of VBN theory, various cultures and beliefs in different countries significantly affect individuals' attitudes towards environmental crises. For example, a study conducted in Russia concerning the environmental attitudes and beliefs of individuals showed an indirect relationship between the acceptability of personal vehicle use

with biospheric values and NEP attitudes. However, a direct relationship was observed between individuals' altruistic values, AC of the effective behaviors on the environment, and individual support for the policy (Unal et al., 2019). Developing and performing VBN theory-related research in Argentina indicated that biospheric, altruistic, and egoistic values are indirectly related to the policies encouraging a reduction in personal vehicle use. However, there was a direct relationship between individuals' altruistic values, AC of the behaviors influencing the environment, and individual support for the policy (Jakovcevic and Steg, 2013). Based on the results of a study that evaluated individuals' environmental beliefs using VBN theory in six urban zones in Norway and transportation mode selection, environmental values and beliefs explain 58% of the variance of personal norms (Lind et al., 2015).

The promotion and development of environmentally friendly transportation was studied by examining individual values in VBN theory through structural equation modeling in Norway during 2019. This study confirmed the significant effect of environmental beliefs on the success of plans for decreasing personal car use and developing nonpolluting transportation (Nordfjærn and Rundmo, 2019). Furthermore, some studies assessed the reduction of vehicle utilization and sustainable transport development under environmental beliefs based on VBN theory criteria in other countries. The results obtained by distributing questionnaires among Chinese drivers indicated that the perceived norms and attitudes significantly affect making decisions to use personal vehicles (Mahpour et al., 2017; Mamdoohi et al., 2016).

3. Methodology

This study employed data from a comprehensive survey conducted in parts of Tehran, Iran, where zonal pricing policies are already implemented. In the present study, environmental attitudes from VBN theory, along with socioeconomic variables, were considered to identify the changes in travel mode under the zonal pricing policy in Tehran. In this regard, the results related to latent environmental variables were provided by using confirmatory factor analysis. A discrete choice model was then developed by quantifying socioeconomic variables as the latent variables. This was done in conjunction with considering the information obtained about individuals' travel modes to examine the effects of pricing policies. Figure 1 displays the VBN theory structure applied in this study (Mahpour et al., 2025a).

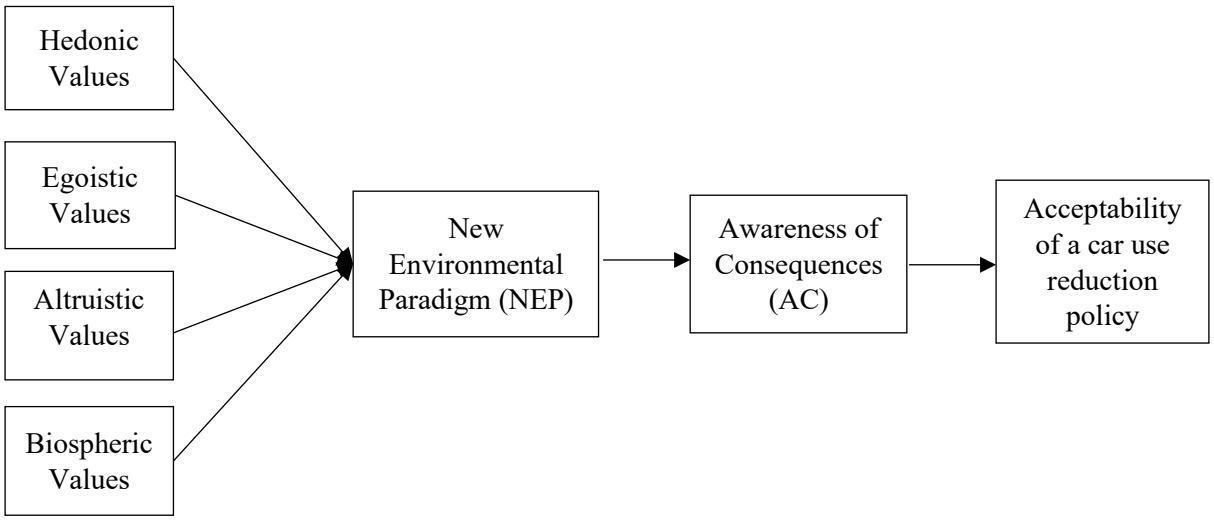

Figure 1. VBN Theory structure in the current study

After examining the results related to factor analysis and quantifying the latent environmental variables, a discrete choice model was created using multinomial logistic regression. This model was developed using environmental variables, as well as individuals' demographic and socioeconomic characteristics, and travel information.

In order to evaluate the changes in individuals' travel mode under the zonal pricing policy, the effects of each group of explanatory variables (i.e., environmental latent variables and individuals' characteristics) on dependent variables were separately examined by implementing confirmatory factor analysis and quantifying the latent variables. Figure 2 displays the final integration of models.

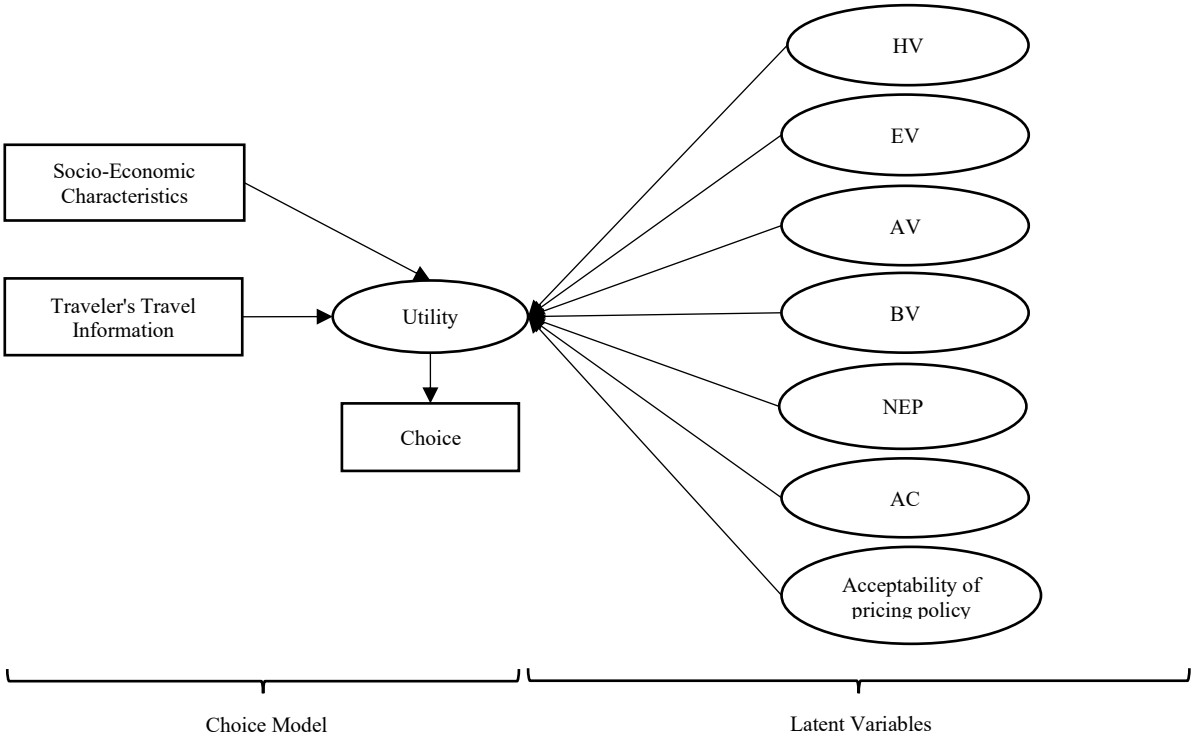

Figure 2. Latent Variable (VBN Theory) and Integrated Choice Model Framework in the current study

4. Data Collection

Tehran, with a population of around 9.1 million and an area of 700 km^2, consists of 22 municipal districts and 650 traffic zones. Every day, approximately 19 million travel trips are conducted, of which 52.4% are compulsory trips (Mahpour et al., 2018). The data collection occurred by distributing a questionnaire among the individuals residing in parts of Tehran known as "air pollution control zones." The traffic congestion and air pollution control zones are located in the central parts of Tehran. These zones were formerly known as the "odd-even plan." Based on the previous plan, vehicles could travel in these restricted zones according to the last number on their plate. Thus, those with even numbers could travel in the restricted zones only during even days (Saturday, Monday, and Wednesday), and those with odd numbers could travel only during odd days (Sunday, Tuesday, and Thursday). In the new plan, private vehicles are allowed to enter the zones 20 times in a season. Additionally, they must pay a certain fee for traveling within the air pollution control zone if the number exceeds the maximum of 20. The traffic congestion zone is a smaller region within the air pollution control zone, and vehicles must also pay a certain fee each time they travel within that zone. Fig. 3 represents the air pollution control and traffic congestion zones.

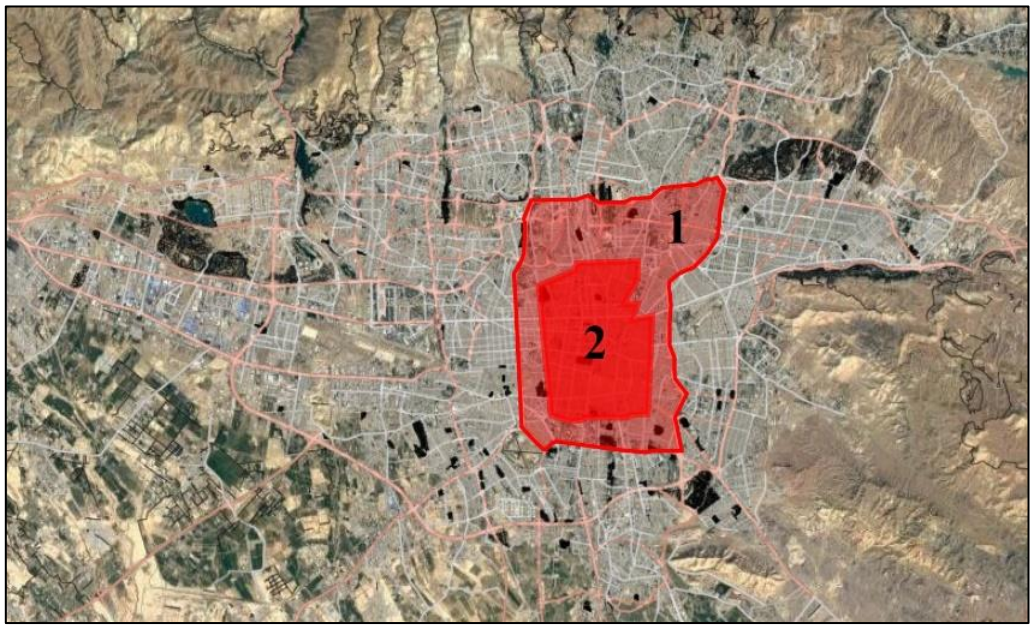

Figure 3. Air Pollution Control Zones (No. 1) and Traffic Congestion Zones (No. 2) in Tehran (Baghestani et al., 2025c)

The questionnaire consisted of six parts. The objectives of the study and confidentiality of information were explained to the individuals before proceeding. In the first part, two questions were asked: "Have you traveled to the traffic congestion zone in the last week?" and "Have you traveled to the air pollution control zone during the recent week?" The second part asked participants about their environmental values and attitudes. In this section, twelve values were grouped under the titles of hedonic, egoistic, biospheric, and altruistic. Participants were asked

to calculate a value orientation index by using a nine-point Likert scale ranging from 1 (strongly against my values) to 7 (strongly aligned with my interests). Additionally, fifteen NEP-related phrases referring to the individuals' attitudes and beliefs towards the environment, five questions regarding individuals' awareness of the consequences of their behavior on the environment, and five questions about the acceptability of the plan for reducing private vehicle use were provided. The latent variables, items, and their sources in the present study are presented in Table 1.

Table 1. Latent variables and indicators

Row	Latent Variable	Indicator	Items	Reference
1	**Hedonic Values (HV)**	Hv1	1- Pleasure	(Steg et al., 2014b, de Groot et al., 2008, Steg et al., 2014a)
		Hv2	2- Enjoying life	
		Hv3	3- Self-indulgence	
2	**Egoistic Values (EV)**	Ev1	1- Social power	
		Ev2	2- Wealth	
		Ev3	3- Authority	
		Ev4	4- Influentiality	
		Ev5	5- Ambition	
3	**Altruistic Values (AV)**	Av1	1- Equality	
		Av2	2- A world at peace	
		Av3	3- Social justice	
		Av4	4- Helpfulness	
4	**Biospheric Values (BV)**	Bv1	1- Respecting the earth	
		Bv2	2- Unity with nature	
		Bv3	3- Protecting the environment	
		Bv4	4- Preventing pollution	
5	**New Environmental Paradigm (NEP)**	Nep1	1- We are approaching the limit of the number of people the Earth can support.	(Dunlap et al., 2000)
		Nep2	2- Humans have the right to modify the natural environment to suit their needs.	
		Nep3	3- When humans interfere with nature, it often produces disastrous consequences.	

Row	Latent Variable	Indicator	Items	Reference
		Nep4	4- Human ingenuity will ensure that we do NOT make the earth unlivable.	
		Nep5	5- Humans are severely abusing the environment.	
		Nep6	6- The Earth has plenty of natural resources if we just learn how to develop them.	
		Nep7	7- Plants and animals have as much right as humans to exist.	
		Nep8	8- The balance of nature is healthy enough to cope with the impacts of modern industrial nations.	
		Nep9	9- Despite our special abilities, humans are still subjected to the laws of nature.	
		Nep10	10- The so-called "ecological crisis" facing humankind has been greatly exaggerated.	
		Nep11	11- The Earth is like a spaceship with minimal room and resources	
		Nep12	12- Humans are meant to rule over the rest of nature.	
		Nep13	13- The balance of nature is very delicate and easily upset	
		Nep14	14- Humans will eventually learn enough about how nature works to be able to control it.	
		Nep15	15- If things continue on their present course, we will soon experience a major ecological catastrophe.	
6	**Awareness of Consequences (AC)**	Ac1	1- Using a car causes the exhaustion of scarce resources such as oil	(Jakovcevic and Steg, 2013; de Groot et al., 2008)
		Ac2	2- Using a car takes up a lot of space, resulting in less space for cyclists, pedestrians, and children.	
		Ac3	3- Using a car is an important cause of traffic-related accidents	

Row	Latent Variable	Indicator	Items	Reference
7	**Acceptability of Car Use Reduction Policy (ACP)**	Ac4	4- Using a car reduces the urban quality of life due to traffic noise and odor nuisance.	(de Groot et al., 2008)
		Ac5	5- The level of air pollution decreases by reducing car use	
		Acp1	1- I would protest against it	
		Acp2	2- I would resign myself to do it	
		Acp3	3- I would accept it	
		Acp4	4- I would feel that the policy was unfair to me	
		Acp5	5- I would agree with it	

In the third part, the respondents were requested to consider their last travel into the air quality control zone. The questions were related to travel purpose, mode, origin, and final destination. Participants were asked about average out-of-pocket costs (while not using private vehicles), as well as the existence of a travel companion, the start and end times of their travel, and the duration of their presence in the zone. The pricing scenarios were offered in the fourth part to evaluate the willingness of individuals to pay these fees for entering the air pollution control zone. In this study, the amounts set for entering the traffic congestion zone based on the different hours of the day in 2016 were applied to provide pricing limits in order to assess the sensitivity of the respondents to various fees, as well as their tendency to travel in the air pollution control zone. Then, a 10-90% increase was added to the base fees in each type of pricing to evaluate individuals' willingness to pay and enter into the air pollution control zone while increasing the level of pollutants. Therefore, sixteen pricing scenarios proposed in the different hours of the day were applied as the policy for pricing the air pollution control zone. This was done in order to examine the tendency of the individuals to pay the intended fees. Table 2 summarizes the final percentages added to the base fees of the 2016 traffic plan as pricing scenarios in this case study.

Table 2. Pricing scenarios in the present study

Type 1 (Enter from 6:30 AM-10:00 AM)	Prices (Iranian Rial)
10%	343,200[a]
20%	374,400
30%	405,600

50%	468,000
Type 2 (Enter from 10:00 AM-2:00 PM)	**Prices (Iranian Rial)**
10%	257,400
25%	292,500
50%	351,000
75%	409,500
Type 3 (Enter from 2:00 PM-6:00 PM)	**Prices (Iranian Rial)**
10%	165,000
25%	187,500
50%	225,000
75%	262,500
100%	300,000
Weekly License (Check in at all hours)	**Prices (Iranian Rial)**
10%	1,100,000
25%	1,250,000
50%	1,500,000

[a] 1 US Dollar equals approximately 900,000 Iranian Rial

In the fifth part, respondents were requested to determine the frequency of using different travel modes (more than 7 times in a week, 4-7 times in a week, 1-3 times in a week, 1-3 times in a month, 4-8 times in a year, and less than 4 times in a year). The final part of the questionnaire included questions related to socioeconomic and demographic characteristics. Table 3 provides a summary of these variables.

Table 3. Summary of socioeconomic variables in the present study (sample size= 500)

Variable	Category	Cumulative Frequency	Relative Frequency (%)
Gender	Female	213	42.6
	Male	287	57.4
Age	18-24	80	16.0

Variable	Category	Cumulative Frequency	Relative Frequency (%)
	25-34	157	31.4
	35-44	135	27.0
	45-54	76	15.2
	55-64	42	8.4
	+65	10	2.0
Education	Middle School Degree	43	8.6
	High School Diploma	111	22.2
	Associate	111	22.2
	Bachelor	168	33.6
	Master	58	11.6
	Doctoral	9	1.8
Occupation	Jobless	122	24.4
	Retired	26	5.2
	Government Employees	36	7.2
	Private Sector Employee	99	19.8
	Self-employed	194	38.8
	Physicians	5	1.0
	Engineer	11	2.2
	Faculty member	0	0.0
	Other	7	1.4
Driving license	Yes	437	87.4
	No	63	12.6
Do you have an independent income?	Yes	378	75.6
	No	122	24.4
Household size	1	46	9.2
	2	107	21.4
	3	176	35.2

Variable	Category	Cumulative Frequency	Relative Frequency (%)
Monthly Income	4	137	27.4
	5 and more	34	6.8
	10 million Rials	15	3.0
	10-20 million Rials	98	19.6
	20-30 million Rials	141	28.2
	30-40 million Rials	129	25.8
	40-50 million Rials	89	17.8
	50-100 million Rials	22	4.4
	More than 100 million Rials	6	1.2
Number of Cars	0	52	10.4
	1	334	66.8
	2	102	20.4
	3+	12	2.4
Family-Owned Car Prices	Less than 200 million Rials	97	19.4
	200-500 million Rials	240	48.0
	500-1000 million Rials	83	16.6
	More than 1000 million Rials	28	5.6
The Purpose of the Trip	Work	232	46.4
	Education	43	8.6
	Shopping	39	7.8
	Recreation	34	6.8
	Personal Affairs	139	27.8
	Other Purposes	13	2.6

5. Results

The latent variables considered in the present study were examined through confirmatory factor analysis using Amos 25 software (Table 4). The results obtained from the composite reliability (CR) related to the variables in the chain of VBN theory demonstrated an acceptable reliability (above 0.7). In addition, the factor loading of the criteria was significant at $p < 0.001$. The

results obtained from the criteria for evaluating confirmatory factor analysis are represented in Table 5, which indicates an appropriate goodness-of-fit.

Table 4. Estimated Results of Factor Analysis for Value Orientations, NEP, and AC

	Estimate	p-value	CR
Hvalue1 ← HV	1.000	-	
Hvalue2 ← HV	0.756	<0.001	0.849
Hvalue3 ← HV	0.884	<0.001	
Evalue1 ← EV	1.000	-	
Evalue3 ← EV	1.169	<0.001	0.846
Evalue4 ← EV	1.201	<0.001	
Avalue1 ← AV	1.000	-	
Avalue2 ← AV	1.202	<0.001	0.844
Avalue3 ← AV	1.208	<0.001	
Bvalue1 ← BV	1.000	-	
Bvalue2 ← BV	1.321	<0.001	0.897
Bvalue3 ← BV	1.197	<0.001	
NEP15 ← NEP	1.000	-	
NEP11 ← NEP	0.881	<0.001	
NEP7 ← NEP	0.965	<0.001	0.703
NEP3 ← NEP	0.945	<0.001	
NEP5 ← NEP	0.688	<0.001	
AC3 ← AC	1.000	-	
AC4 ← AC	1.027	<0.001	0.833
AC5 ← AC	1.309	<0.001	

Table 5. Evaluation of the Confirmatory Factor Analysis

Indices	CMIN/DF	RMSEA	TLI	CFI	GFI	AGFI
Acceptance Range	Between 1 and 3	≤ 0.07	≥ 0.90	≥ 0.90	≥ 0.90	≥ 0.80

Results	1.620	0.063	0.910	0.912	0.917	0.817

Table 6 presents the results of the multinomial logit model by using environmental attitudes (derived from VBN theory), individuals' characteristics, and travel mode, with three alternatives of not changing the vehicle and switching from a private car to public transit.

Table 6. Results of Multinomial Logit Model

Choice	Variable Symbol	Variable Description	Coefficient	Significance Level
Not Changing the Vehicle	AC	Awareness of consequences (latent variable)	-0.45	0.0000
	HV	Hedonic value (latent variable)	0.85	0.0000
	Price2	Cost per 100,000 Rials	-0.0035	0.0457
	Zttpub	Average travel time of public transportation	24.99	0.0017
	Zstart2	Starting time of the journey after 6:30=1, otherwise=0	-1.08	0.0000
	Zpurp3	Travel purpose (Shopping)=1, otherwise=0	2.96	0.0000
	Zpurp6	Travel purpose (Personal Affairs) =1, otherwise=0	1.49	0.0000
	Nveh	Ranking variable of the number of vehicles in the household	0.55	0.0015
	Vehcost	Ranking variable of the number of vehicle costs	0.75	0.0000
	Empd	Governments Employee=1, otherwise=0	-1.15	0.0000
	Nowor	Jobless=1, otherwise=0	-5.33	0.0000
	Hcar	Ranking variable of traveling using a car more than 7 times in a week or 4-7 times in a week=1, otherwise=0	2.20	0.0000
Altering from a Personal Vehicle to a Bus	CTE	Constant Number	7.64	0.0000
	NEP	NEP Statements (latent variable)	0.88	0.0000
	Zdu	Duration of stay in the zone (all combinations)	-1.01	0.0000

Choice	Variable Symbol	Variable Description	Coefficient	Significance Level
Altering from a Personal Vehicle to the Subway	Nveh1	Number of vehicles in HH (1)=1, otherwise=0	1.23	0.0000
	Vehcost3	Vehicle costs 500-1000 million Rials=1, otherwise=0	-2.05	0.0052
	Std	No income and you are a student=1.otherwise=0	4.00	0.000
	Hhs	Ranking Variable of Household Sizes	-0.24	0.0017
	Edu2	High school degree=1, otherwise=0	1.60	0.0000
	Ibus	Ranking variable of traveling using Bus 4-8 times in a year or less than 4 times in a year	-1.69	0.0000
	CTE	Constant number	7.31	0.0000
	BV	Biospheric value (latent variable)	0.32	0.0001
	Zend2	Ending time of the journey after 6:30=1, otherwise=0	2.78	0.0000
	Zdu4	Duration of stay in the zone more than 3 hours=1, otherwise=0	-1.06	0.0000
	Vehcost4	Vehicle costs more than 1000 million Rials=1, otherwise=0	-4.60	0.0000
	Indinc	Having an independent income=1, otherwise=0	-1.10	0.0000
	Edu4	Master's degree=1, otherwise=0	0.66	0.0000
	Hsub	Ranking variable of traveling using Subway: More than 7 times in a week or 4-7 times in a week, otherwise=0	1.55	0.0000
Evaluation Criteria	$LL(\beta)$	-1015.30667		
	ρ_c^2	0.4016		
	ρ_{adj}^2	0.3967		

As shown in Table 6, the effect of travel costs associated with utilizing a personal vehicle in the air pollution control zone is negative and significant (-0.0035) in the acceptability of not changing vehicles. The issue demonstrates a decrease in the tendency to utilize private vehicles by raising the fees of the air pollution control plan. Additionally, an increase in the mean

duration of traveling by public transportation increases the probability of choosing a personal vehicle. In other words, the individuals compared the duration of travel completed by personal vehicles and public transportation and preferred to use their personal vehicles if traveling via public transportation took too long (the consequence of a lack of good public transportation coverage).

Based on the results, the influence of AC on not changing a vehicle was obtained as negative. In fact, those having such attitudes were less inclined to drive their personal vehicle. This variable indicates individuals' awareness of the environmental consequences of their activities (Unal et al., 2019, Liu et al., 2017). This demonstrates these individuals are fully aware of the environmental consequences of their personal vehicle usage, feel greater responsibility for conserving environmental resources, and attempt to obtain more information about the outcomes of their activities on the environment (Hiratsuka et al., 2018, Cools et al., 2011). The researchers believe that people's unawareness of the consequences of their actions on the environment is one of the critical issues leading to their inattention to the environment (Odeck and Kjerkreit, 2010). Improving their awareness of this topic is suggested by incentive programs such as community engagement and public advertisements (e.g., Tayarani Yousefabad et al., 2022; Tayarani Yousefabad et al., 2021).

Regarding the alternative of continuing private vehicle use, HV with a positive sign was determined as significant. This variable demonstrates hedonism and individual values, reflecting those who paid more attention to themselves and cared less about other people, as well as the environment, and their behavior is formed based on benefit-seeking. Accordingly, these persons more often used personal vehicles regardless of environmental issues.

The positive sign of BV in the alteration from personal vehicle use to buses represented the higher probability of choosing vehicles by those having such attitudes. The latent variable indicates individuals' concerns about the environment. Those who felt more responsibility for preserving environmental resources attempted to select environmentally friendly alternatives such as public transit. Those with a stronger environmental view had a better cognitive orientation towards the environment. They represent greater environmental sensitivity by considering that nature and other organisms, as a part of the larger universe, have their specific rights and values, and the environment should not be exploited as an instrumental value and profitable resource.

Based on the results of the model, the sign of NEP in altering travel modes from personal vehicles to a public transportation bus was obtained as positive, reflecting the higher environmental friendliness of buses compared to that of a personal vehicle. Thus, these respondents were more likely to choose riding the bus.

Regarding the cases in which the respondent started to work in the air pollution zone at the peak hours of the morning (6:30-10), the probability of not selecting to change the vehicle decreased because of imposing a greater cost on the individual. The probability of choosing the

metro by those who worked at these hours increased due to the congestion of the metro in the opposite direction (entering the air pollution control zone).

The possibility of selecting a personal vehicle was higher among the respondents who were traveling to the air pollution zone for shopping or taking care of personal issues. Due to the characteristics of such trips, these travelers could better organize their activities by using personal vehicles compared to public transit. These findings resonate with evidence from ride-hailing studies during pandemics, where trip purposes such as shopping or mandatory activities significantly shaped adoption likelihood (Baghestani et al., 2025b).

Based on assessing the sign of Zdue (ordinal variable showing the duration of presence in the air pollution zone) and Zdu4 (dummy variable when the duration is more than three hours), the respondents' willingness to use public transit (bus and metro) decreased while spending greater time in the zone. Longer travels were usually more complex and possessed a longer chain of travel from destination to destination. Consequently, travelling with a personal vehicle was considered more appropriate than using the bus and/or metro.

In the present study, the number of personal vehicles owned by a household, as well as their approximate price and mean family expenditure, were used as an income proxy. The previous studies reported a higher tendency to use personal vehicles for higher-income individuals (Hess and Börjesson, 2016). The sign related to the number of private vehicles owned by the household (NVEH) and their approximate cost (vehcost) was determined as positive in not changing the vehicle, which is consistent with the result of other studies. Those with more income continued to use personal vehicles. Further, two dummy variables of vehcost3 (the approximate cost of household-owned cars is 500-1000 million Rials) and vehcost4 (the approximate cost of household-owned cars is above 1000 million Rials) were negative and significant in selecting between riding the bus and metro, respectively. Individuals who owned expensive vehicles were considered part of an affluent class and were less inclined to utilize public transportation, which is in line with the results of other studies (Hess and Börjesson, 2016; Baghestani et al., 2025a). Those with one personal vehicle in their household (NVEC1) (middle class) were more likely to ride the bus.

The probability of using a private vehicle by government staff and the unemployed was low, and the university students showed more willingness to utilize the bus. Additionally, the respondents who had independent incomes were less inclined to use the metro. The acceptability of riding the bus is reduced by increasing family size. Those holding diplomas and bachelor's degrees as their last educational degree were more likely to use the bus and metro, respectively (Baghestani et al., 2025a).

6. Summary and Conclusion

Travel demand management (TDM) is an effective approach to alleviate traffic congestion and reduce air pollution. Heightened awareness of air pollution's negative effects on health and well-being has amplified community concerns about environmental issues. These concerns

enhance the efficiency of TDM policies through positive public reactions, particularly during environmental crises. In this regard, this study employed four groups of variables related to individuals' values, beliefs, and norms to evaluate mode shifts from personal vehicles to public transportation (metro and bus) under zonal pricing policies. Specifically, it assessed environmental-related latent variables using Value-Belief-Norm (VBN) theory to model travelers' attitudes toward mode changes under TDM policies.

The latent variables encompassed the VBN theory chain, grounded in environmentally friendly activities, including environmental values and beliefs. These were integrated with socioeconomic variables and travel characteristics to model mode shifts under zonal pricing, as a key TDM method.

Results showed that the latent variable Awareness of Consequences (AC), representing awareness of environment-related behavior consequences, was inversely related to personal vehicle selection before and after policy implementation. Thus, precise public transportation policies in metropolitan areas, such as reducing headways, enhancing comfort, and improving access, can minimize personal vehicle use among environmentally aware individuals. Additionally, a direct relationship between Biospheric Values (BV) and the New Environmental Paradigm (NEP) index, with public transportation use, validated the study's predictions, aligning earth-centric values with clean transport adoption. Conversely, Hedonic Values (HV), focused on individual pleasures, correlated with personal vehicle use.

A direct link was also observed between personal vehicle and public transit choices and trip temporal distribution. For instance, individuals less inclined to use public transport on weekdays exhibited higher personal vehicle tendencies before and after zonal policies. Factors like long headways and irregular services likely drive this preference for personal vehicles.

These findings offer transportation decision-makers a clear perspective: developing clean transport and reducing private vehicle dependency can gain community acceptance during environmental challenges. Public perceptions and beliefs about crises can facilitate policies to curb private vehicle reliance. Zonal and road pricing policies emerged as effective tools for addressing increased travel time, environmental pollution, and congestion. Revenue from these policies can be reinvested in public transport upgrades, creating a positive feedback loop of improved service and greater public acceptance.

This study modeled individuals' environmental attitudes and socioeconomic variables, examining their distinct effects on mode changes under TDM. Future research should develop integrated models accounting for individual variability, heterogeneity, and deeper decision-making insights in other metropolitan areas. Studies targeting specific groups, such as students or sector employees, and comparing attitudes across domains, are recommended.

7. References

Akbari, F., Mahpour, A. & Ahadi, M. 2020. Evaluation of energy consumption and CO_2 emission reduction policies for urban transport with system dynamics approach. *Environmental Modeling & Assessment,* 25.

Annika, N. & Garvill, J. 2003. Effects of values, problem awareness, and personal norm on willingness to reduce personal car use. *Journal Of Environmental Psychology,* 23**,** 339-347.

Ahadi, M.R., Mahpour, A.R. and Taraghi, V., 2018. A Combined Fuzzy Logic and Analytical Hierarchy Process Method for Optimal Selection and Locating of Pedestrian Crosswalks. *Journal of Optimization in Industrial Engineering*, *11*(2), pp.79-89.

Baghestani, A., Heshami, S. & Mahpour, A. 2025a. A decision tree approach for modal shift from online taxi to private car during the COVID-19 pandemic. *Iranian Journal Of Science And Technology, Transactions Of Civil Engineering*.

Baghestani, A., Heshami, S. & Mahpour, A. 2025b. The impact of pandemic experiences on future similar situations: analysis of latent variables and trip purposes in ride-hailing choice. *Transportation Planning And Technology***,** 1-20.

Baghestani, A., Heshami, S., Mahpour, A., Sadeghitabar, S. & Borhani, R. 2025c. Behavioral intentions towards ride-hailing services during the pandemic: using the health belief model and the moderating role of health norms and age. *Journal Of Transport & Health,* 44**,** 102153.

Cipriani, E., Mannini, L., Montemarani, B., Nigro, M. & Petrelli, M. 2018. Congestion pricing policies: design and assessment for the city of Rome, Italy. *Transport Policy,* 80.

Cleveland, M., Kalamas, M. & Laroche, M. 2005. Shades of green: linking environmental locus of control and pro-environmental behaviors. *Journal Of Consumer Marketing,* 22**,** 198-212.

Cools, M., Brijs, K., Tormans, H., Moons, E., Janssens, D. & Wets, G. 2011. The socio-cognitive links between road pricing acceptability and changes in travel behavior. *Transportation Research Part A: Policy And Practice,* 45**,** 779-788.

De Groot, J. & Steg, L. 2009. Morality and Prosocial Behavior: The role of awareness, responsibility, and norms in the norm activation model. *The Journal Of Social Psychology,* 149**,** 425-49.

De Groot, J., Steg, L. & Dicke, M. 2008. Transportation trends from a moral perspective: value orientations, norms and reducing car use.

De Vos, J. 2016. Road pricing in a polycentric urban region: analysing a pilot project in Belgium. *Transport Policy,* 52**,** 134-142.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. 2000. New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal Of Social Issues,* 56**,** 425-442.

Gkargkavouzi, A., Halkos, G. & Matsiori, S. 2019. Environmental behavior in a private-sphere context: integrating theories of planned behavior and value, belief, norm, self-identity, and habit. *Resources Conservation And Recycling*.

Glavic, D., Mladenovic, M., Cicevic, S. & Trifunović, A. 2017. Road to price: user perspectives on road pricing in transition countries. *Transportation Research Part A Policy And Practice,* 105**,** 79-94.

Grelier, F. & Engineer, C. V. 2018. 2018 Annual report: transport & environment. brussels, belgium: t*ransport & Environment.*

Hess, S. & Börjesson, M. 2016. Understanding attitudes towards congestion pricing: a latent variable investigation with data from four cities. *Transportation Letters: The International Journal of Transportation Research,* 11.

Hiratsuka, J., Perlaviciute, G. & Steg, L. 2018. Testing VBN theory in Japan: relationships between values, beliefs, norms, and acceptability and expected effects of a car pricing policy. *Transportation Research Part F Traffic Psychology And Behaviour,* 53**,** 74-83.

Jakovcevic, A. & Steg, L. 2013. Sustainable transportation in Argentina: values, beliefs, norms, and car use reduction. *Transportation Research Part F: Traffic Psychology and Behaviour,* 20**,** 70-79.

Kiatkawsin, K. & Han, H. 2017. Young travelers' intention to behave pro-environmentally: merging the value-belief-norm theory and the expectancy theory. *Tourism Management,* 59**,** 76-88.

Lind, H., Nordfjærn, T., Jørgensen, S. & Rundmo, T. 2015. The value-belief-norm theory, personal norms, and sustainable travel mode choice in urban areas. *Journal of Environmental Psychology,* in press.

Lindsey, R. 2003. Road pricing issues and experiences in the us and Canada.

Liu, Y., Sheng, H., Mundorf, N., Redding, C. & Ye, Y. 2017. Integrating norm activation model and theory of planned behavior to understand sustainable transport behavior: evidence from China. *International Journal of Environmental Research and Public Health*, 14.

Mahpour, A., Forsi, H., Vafaeenejad, A. and Saffarzadeh, A., 2022a. An improvement on the topological map matching algorithm at junctions: a heuristic approach. *International journal of transportation engineering*, *9*(4), pp.749-761.

Mahpour, A., Vafaeenejad, A. and Forsi, Z., 2022b. Analysis and evaluation of metaheuristic, heuristic, and deterministic methods in providing an optimal path for small, medium, and large networks. *Road*, *30*(110), pp.1-10.

Mahpour, A., Amiri, A.M., Deldar, M., Saffarzadeh, M., and Nazifi, A., 2018. A heuristic method to determine traffic bottlenecks based on ant colony: a case study of Iran. *Case Studies on Transport Policy*, *6*(4), pp.716-721.

Mahpour, A.R. and Saeedi Shahrivar, S., 2022. Investigating the role of latent individual components in the acceptance of demand management policies: Case study of Tehran odd-even policy. *Sharif Journal of Civil Engineering*, *38*(3.1), pp.41-52.

Mahpour, A., Hossein Rashidi, T. and Saffarzadeh, M., 2017. Modeling integrated clothing shopping destination choice using structure equation models. *Modares Civil Engineering journal*, *17*(3), pp.158-170.

Mamdoohi, A., Axhausen, K. W., Mahpour, A., Rashidi, T. H. & Saffarzadeh, M. 2016. Are there latent effects in shopping destination choice?. survey methods and response behavior. *16th Swiss Transport Research Conference (Strc 2016), Ascona, Switzerland, May 18-20, 2016.* swiss transport research conference (strc).

Miller, D., Merrilees, B. & Coghlan, A. 2014. Sustainable urban tourism: understanding and developing visitor pro-environmental behaviours. *Journal of Sustainable Tourism,* 23**,** 26-46.

Nordfjærn, T. & Fallah Z, M. 2017. Does the value-belief-norm theory predict acceptance of disincentives to driving and active mode choice preferences for children's school travels among Chinese parents? *Journal Of Environmental Psychology,* 53.

Nordfjærn, T. & Rundmo, T. 2019. Acceptance of disincentives to driving and pro-environmental transport intentions: the role of value structure, environmental beliefs, and norm activation. *Transportation,* 46**,** 2381-2396.

Odeck, J. & Kjerkreit, A. 2010. Evidence on users' attitudes towards road user charges--a cross-sectional survey of six norwegian toll schemes. *Transport Policy,* 17**,** 349-358.

Steg, L., Bolderdijk, J., Keizer, K. & Perlaviciute, G. 2014a. An integrated framework for encouraging pro-environmental behaviour: the role of values, situational factors and goals. *Journal Of Environmental Psychology,* 38**,** 104-115.

Steg, L., Perlaviciute, G., Van Der Werff, E. & Lurvink, J. 2014b. The significance of hedonic values for environmentally relevant attitudes, preferences, and actions. *Environment And Behavior,* 46**,** 163-192.

Stern, P. 2000. Toward a coherent theory of environmentally significant behavior. *Journal Of Social Issues,* 56**,** 407-424.

Tayarani Yousefabadi, A., Mahpour, A. and Javanshir, H., 2020. Modeling share change of non-public vehicles and the rate of emissions due to the implementation of demand management policies. *Journal of Transportation Research*, *17*(3), pp.203-216.

Tayarani Yousefabadi, A., Mahpour, A., Farzin, I. and Mohammadian Amiri, A., 2021. The assessment of the change in the share of public transportation by applying transportation demand management policies. *AUT Journal of Civil Engineering*, *5*(2), pp.199-212.

Unal, A., Steg, L. & Granskaya, J. 2019. “To support or not to support, that is the question”. testing the VBN theory in predicting support for car use reduction policies in Russia. *Transportation Research Part A: Policy And Practice,* 119**,** 73-81.

Van Der Werff, E. & Steg, L. 2016. The psychology of participation and interest in smart energy systems: comparing the value-belief-norm theory and the value-identity-personal norm model. *Energy Research & Social Science,* 22**,** 107-114.

Unal, A., Steg, L. & Granskaya, J. 2019. “To support or not to support, that is the question”. testing the VBN theory in predicting support for car use reduction policies in Russia. *Transportation Research Part A: Policy And Practice,* 119**,** 73-81.

Van Der Werff, E. & Steg, L. 2016. The psychology of participation and interest in smart energy systems: comparing the value-belief-norm theory and the value-identity-personal norm model. *Energy Research & Social Science,* 22**,** 107-114.