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A Short Review of Behavioral Intention and Factors Using the Theory of Planned Behavior and Data Mining Techniques

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Abstract:

The growing need for urban mobility alongside environmental issues has undertaken several investigations into the factors that lead people to abandon private cars in favour of public transportation. The Theory of Planned Behavior (TPB) is one of the most developed theories in regard to behavioral intentions that explain decision-making processes considering attitude towards the behavior, social pressure, and perceived control over the action impact choices regarding transportation. There has been some progress in extending TPB by adding constructs such as concern for the environment, moral standards, and previous actions taken, which strengthens the explanation. At the same time, the combination of data mining techniques and machine learning, such as structural equation modeling, decision tree, and support vector machine, has led to better prediction of travel behavior as well as providing greater understanding into the behavior. This work reviews empirical research applying TPB alongside data-driven methods to plan shifts towards public transport and analyses the methodology used. It reveals the dominant influence of socio-psychological factors and other elements related to information technologies on transport behavior and shows new possibilities offered by modern analytical methods aimed at policy decisions. In conclusion, the paper offers new approaches and focus of studies, arguing that models need to be tailored to certain conditions, and that advanced technologies should be adapted to encourage sustainable transport.

Keywords- Theory of Planned Behaviour, Behavioural Intention, Data Mining

Introduction:

Urban transportation systems face growing challenges due to the increased reliance on private vehicles, leading to traffic congestion, environmental degradation, and energy inefficiencies. To address these issues and promote sustainable urban mobility, policymakers and researchers have turned their attention to encouraging a modal shift from private vehicles to public transportation. Understanding the underlying psychological and behavioral factors that influence individuals' travel mode choices is essential for developing effective strategies.

The Theory of Planned Behavior (TPB), introduced by Ajzen (1991), has been widely adopted to explain and predict human behavior, particularly in the context of transportation. According to TPB, an individual's behavioral intention—the strongest predictor of actual behavior—is shaped by three key constructs: attitude toward the behavior, subjective norms, and perceived behavioral control. In transport studies, these constructs are used to evaluate individuals' perceptions and intentions toward using public transit over private modes.

Numerous studies have applied TPB and its extensions to investigate the intention to shift to public transport. These studies often incorporate additional factors such as environmental concern, personal norms, past behavior, and perceived service quality to enhance the predictive power of the model. Alongside TPB, the use of data

mining techniques and machine learning algorithms—including decision trees, support vector machines, random forests, and structural equation modeling (SEM)—has facilitated deeper insights into travel behavior by uncovering hidden patterns in large datasets.

This review paper aims to synthesize the current body of literature that applies the Theory of Planned Behavior and data mining techniques to analyze behavioral intention and mode shift toward public transportation. By identifying prevailing themes, methodological approaches, and research gaps, this paper seeks to provide a comprehensive foundation for future studies and inform policy interventions aimed at promoting sustainable transport choices.

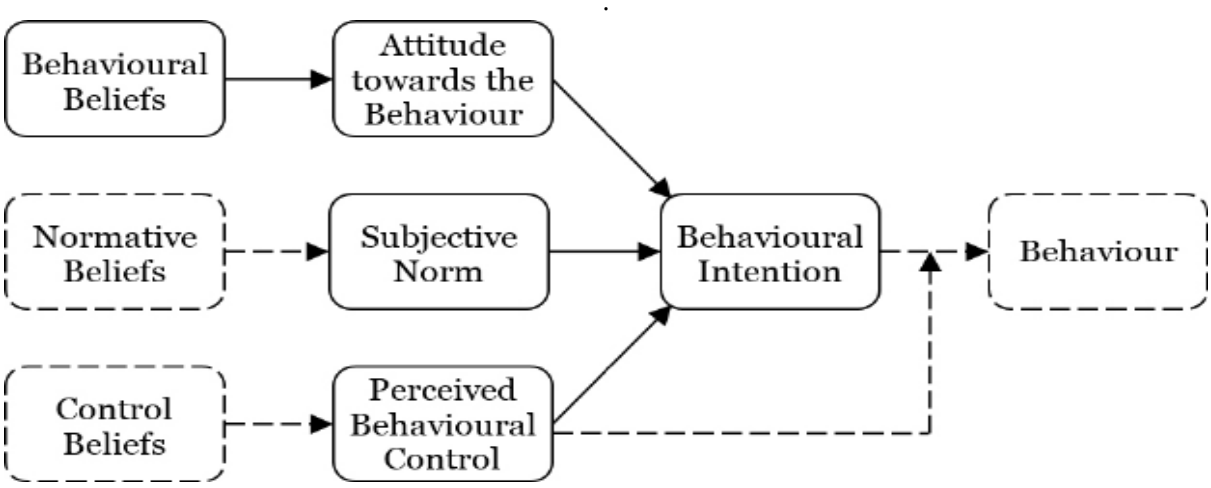

Figure 1: The Theory of Planned Behavior (Ajzen, 1985, 1991)

Literature Review

Ajzen and Driver (1992) explored the concept of contingent valuation measurement by treating willingness to pay (WTP) for public goods as a behavioral intention, utilizing the Theory of Planned Behavior. They collected data from 150 undergraduate students at the University of Massachusetts through a questionnaire focused on various outdoor recreational activities. This questionnaire addressed five leisure activities: spending time at the beach (including sunbathing, surfing, playing games, etc.), outdoor jogging or running, mountain climbing, boating, and biking. The questionnaire included two sets of questions aimed at studying two types of behavior: participation in the five recreational activities and willingness to pay a fee for each activity. Participants rated their intention to pay to engage in these activities over the next 12 months using two 7-point semantic differential scales. These scales assessed both their intentions to pay and their perceived behavioral control relating to each recreational activity. Additionally, twelve items were created to evaluate attitudes toward these behaviors. The second part of the questionnaire examined the willingness to pay a reasonable user fee to take part in these activities. This section included items addressing moral or ethical considerations and three measures of WTP. The study concluded that in the absence of relevant knowledge or information about the economic value of public goods, willingness to pay often relies on cognitive heuristics; furthermore, more substantial considerations come into play when determining the amount of money to be paid.

Ambak et al. (2016) investigated behavioral intentions to use public transport, particularly public buses, through the lens of the Theory of Planned Behavior. They distributed 282 questionnaires in selected areas of Batu Pahat and Kluang to identify factors influencing users to utilize public buses and to determine the most dominant factors according to TPB. The questionnaire was divided into three sections: respondent information, perceived quality of public bus services, and intention to use public buses based on TPB. Respondents rated each item on a five-point Likert scale, with 1 being "totally disagree" and 5 being "totally agree." The study conducted two levels of regression analyses: first, multiple regression analyses to explore relationships between intention and the constructs of attitude, subjective norms, and perceived behavioral control; and second, simple regression analysis to assess the relationship between behavior and intention. The results indicated that a positive attitude

toward cost savings and the absence of alternative travel options would encourage the use of public transport (buses).

E.L. Bird et al. (2018) examined observational data to predict changes in walking and cycling behavior related to transportation and recreation, utilizing an extended version of the Theory of Planned Behavior. The iConnect survey data were collected through baseline, one-year, and two-year follow-up surveys from three municipalities in the UK. A total of 3,516 participants completed and returned the baseline survey, which employed a nine-item measure based on a five-point Likert scale. The study also used multinomial logistic regression to analyze the relationship between the baseline extended TPB constructs and changes in four behavioral outcomes. The findings indicated that all constructs of the extended TPB model were positively related to change in at least one of the four walking and cycling outcomes.

Haustein et al. (2016) examined psychological factors influencing road traffic congestion with a focus on the Theory of Planned Behavior in relation to departure time choices. They conducted an online questionnaire targeting car users in Copenhagen to gather data on travel behavior, stated preferences, psychological variables, and background information. Each construct was measured using a five-point Likert scale consisting of three items. Although over 10,000 questionnaires were distributed, only 286 met the eligibility criteria. A discrete choice model was also incorporated to enhance understanding and modeling of departure time choices. The findings revealed that the impact of psychological factors varied based on specific conditions: for individuals with fixed work start times, the intention to arrive on time was the most significant predictor, whereas for those with flexible hours, the attitude towards shorter travel times was more relevant.

Spumont and Viti (2018) investigated the impact of workplace relocation on daily travel behavior. They utilized two travel diaries—one from before the relocation and one after—for two continuous weeks to collect detailed data on trip chaining behavior. The study involved 43 employees from the University of Luxembourg who transitioned between the old and new campus locations during the 2015-16 academic year. To assess the effects of workplace relocation on daily activities, the Standard Deviation Ellipses (SDE) approach was employed. A total of 86 ellipses (one per respondent for all working days before and after the relocation) were generated using ArcGIS software. The results indicated that after relocating, very few individuals engaged in activities in the old campus area, which also notably impacted commuting distances, mode choices, and commuting times.

Claudy and Peterson (2014) explored the underutilization of urban bicycle commuting through the lens of behavioral reasoning by applying a novel consumer behavior model known as Behavioral Reasoning Theory (BRT). This study examined how consumers' values, attitudes, and the reasons for and against bicycling influence their decision to commute by bicycle. Data were collected and analyzed from 936 commuters in Dublin, Ireland, using a five-point Likert scale. Confirmatory factor analysis conducted with SPSS AMOS 18 suggested a low likelihood of common method variance. The hypotheses were tested using the 936 responses, and to establish the model's robustness, a series of nested models were examined. The results indicated that BRT offers a valuable framework for social marketers and policymakers aiming to understand and promote sustainable behavior in personal transportation.

Fillone and Mateo-Babiano (2018) investigated the factors that affect an individual's decision to walk or take a pedicab (also known as a cycle rickshaw) as their preferred option for first and last-mile trips. This study was conducted in the Ermita district of Manila City, Philippines. Based on high demand and supply of pedicabs, significant pedestrian foot traffic, and areas with mixed land use, ten locations were identified for the survey. The walk-to-pedicab ratio was calculated as 1:15, with 270 samples for pedicab users and 4,163 samples for pedestrians, obtained by counting the number of pedicabs and pedestrians passing through specific intercept points during the morning peak hours from 7 am to 8 am on weekdays. At these locations, face-to-face interviews were conducted with respondents to inquire about their preferences between the two modes of transportation, in order to understand the factors influencing their choices. It was noted that two out of five pedicab users and pedestrians declined to participate in the interview, and some pedicab users were skipped due to the lengthy nature of the survey. Respondents provided information on their mode preferences, travel behavior, socio-demographic details, and attitudes toward their choices for first and last-mile options. A total of

700 participants were initially surveyed, but only 575 samples were considered valid, as incomplete samples were excluded. The socio-demographic attributes examined included gender, civil status, work status, trip purpose, age, and income. The survey results indicated that the proportion of female pedicab users was 61.8%, while male pedestrians slightly outnumbered females at 53.5%. Using Logit choice analysis, statistically significant mode-specific and qualitative variables were identified to develop the choice model. Variables considered in the choice modeling included mode and route-specific factors such as alternative specific constant, access or egress travel time, cost of travel by pedicab, wait time for pedicabs, out-of-pocket costs, distance versus safety rating, perceived safety rating, walkway accessibility rating, and environmental condition rating of the walkway. Generic variables included gender, age, presence of a child companion, work status, and having baggage. Among these factors, the most significant ones were access or egress time, cost relative to travel time, safety, and overall travel time. The cross-tabulation matrix indicated that the predicted model correctly identified 79.9% of pedestrian choices and 65.6% of pedicab choices. Overall, 74.6% (429 out of 575) of mode choices were accurately predicted.

Aditjandra et al. (2016) analyzed changes in public transport use and walking following residential relocation, which highlighted the relationship between land use and travel behavior. This analysis utilized quasi-longitudinal household survey data from ten communities in North East England. A structural equation model (SEM) was used to examine the causal relationships among various multi-dimensional factors related to land use and travel behavior. Data were collected based on respondents' socio-demographic variables, including gender, age, economic status, educational background, household income, household size, and the number of children, as well as changes in these factors before and after relocation. To assess changes in travel behavior, a questionnaire was developed using a five-point scale. The study revealed that 219 respondents had moved to their current location within the last eight years. Neighborhood characteristics and preferences were measured using a four-point scale, with respondents evaluating their previous and current neighborhoods. Factor analysis was conducted to explore the relationship between neighborhood characteristics and travel attitudes, using continuous variables in the structural model. Seven factors were identified for neighborhood characteristics: safety, travel accessibility, residential spaciousness, social factors, shopping/facility accessibility, outdoor space accessibility, and neighborhood unattractiveness. Meanwhile, eight factors were considered for travel attitudes, including pro-public transport use, travel minimizing awareness, dislike of cycling, positive utility of travel, safety of car travel, pro-walking, dislike of travel, and car-dependency. The study applied structural equation models and ordered logit models to understand the relationship between neighborhood design and travel behavior, particularly in terms of changes in public transport use and walking. The findings suggested that different approaches are needed to promote public transport use compared to increasing walking trips, emphasizing the importance of changes to the built environment to encourage walking.

Schneider (2015) identified characteristics of the local environment that are associated with walking and transit use to shopping districts. He considered factors such as travel characteristics, socioeconomic characteristics, attitudes and perceptions, and shopping district characteristics. Travel data was collected from retail pharmacy store customers in 20 shopping districts in the San Francisco Bay Area between August 29, 2009, and December 9, 2009, under the assumption that customers utilized a variety of travel modes. Using cluster analysis with variables like population, employment, sidewalk coverage, lanes on the main shopping street, driveway crossings, and parking spaces at stores, four shopping districts were identified. A total of 4,585 customers were invited to participate in the survey, and 1,003 customers took part. The survey was conducted through verbal questions, and responses were recorded. Out of the 1,003 customers, 959 provided complete tour data. The survey took into account socioeconomic characteristics, attitudes toward different travel modes, perceptions of crash and crime risk within the shopping district, and the locations of respondents' residences and shops. All modes of transportation used to travel between each activity location, including movements within the shopping district, were reported. Of the participants, 397 stopped their tour within the same shopping district. Among these, 192 used an automobile as their primary travel mode, 167 walked, 29 used transit, and 9 rode bicycles. Mixed logit models were employed to identify variables associated with mode choices. A total of 388 respondents were considered for the mixed logit model, excluding bicycle users due to their small number. The final mixed logit model included 27 parameters: constant, travel time, out-of-pocket cost, number of tour stops,

distance traveled within the shopping district with and without bags, shopping alone, lower household income, students, group housing, Spanish speakers, disabilities, enjoyment of walking, perceived shopping district crash risk, employment, population, survey store parking spaces, distance to the train station, and multilane roads with tree canopy. The results concluded that the distance traveled by respondents within the shopping district was positively associated with traveling from the shopping district by automobile. Respondents were significantly more likely to walk and use transit than to drive to the shopping district. There was also a significant positive association between respondents' perceived risk of pedestrian crashes in the shopping district and their likelihood of walking and using transit. Employment density showed a negative association with automobile mode choice, while population, parking spaces, and tree canopy were positively associated with automobile users.

Health and Gifford (2002) used an expanded version of the Theory of Planned Behavior (TPB) to predict and explain public transportation use. This study focused on student bus ridership after the implementation of a U-Pass program, examining students' attitudes toward their transportation modes, descriptive norms, and the interaction between intention and perceived behavioral control. Two surveys were conducted in phases for this investigation: one during the summer of 1999 and another in October 1999 at a medium-sized university in Western Canada. A 5-point questionnaire was used in both phases, with approximately 1,020 questionnaires distributed to male and female participants. The response rate included 56.8% females and 41.8% males. Hierarchical multiple regression analysis was employed, confirming the positive influence of performing a behavior on psychological factors, as well as the reciprocal nature of the influence between psychological factors and behavior performance.

Collins, Witkiewitz, and Larimer (2011) identified predictors of growth in risky drinking behaviors among college students over a three-month period using the Theory of Planned Behavior. The study aimed to predict the intention to engage in risky drinking, which subsequently predicted the increase in such behaviors. A total of 837 college students (64.2% female) from two universities on the West Coast of the U.S. participated, with a mean age of 20.15 years (SD = 1.39). Data were collected through a questionnaire that included personal information, behavioral norms, normative beliefs, and perceived behavioral control, using both 9-point and 5-point scales. The Timeline Followback questionnaire was employed to create aggregate indicators of risky drinking, such as peak drinking quantity and frequency of heavy episodic drinking, organized on a monthly calendar. The survey was administered using the web-based software program DatStat Illume, which allowed for the creation and modification of the online assessment. Logistic regression analyses, Chi-square tests, and fit indices confirmed a close fit for the models. Participant retention rates were 86% at the one-month follow-up and 78% at the three-month follow-up.

DeMaria, Sundstrom, Saxon, Faria, and Ramos-Ortiz (2019) compared the effectiveness of the combined oral contraceptive pill (COC) and the long-acting reversible contraceptive (LARC) method among college women. A questionnaire utilizing the Theory of Planned Behavior was distributed to 482 college-aged women in the Southeastern United States. Of the 482 completed surveys, 186 participants were current COC users, with a mean age of 20.0 years. A 7-point scale was used in the TPB survey. Structural equation modeling (SEM) was applied to assess LARC intentions, resulting in model fit statistics indicating a significant model ($p < 0.01$, CFI = 0.84, NFI = 0.75, RMSEA = 0.09). Additionally, self-identity was tested, yielding results ($p < 0.01$, CFI = 0.83, NFI = 0.73). These findings suggest that the TPB effectively captures COC users' intentions to seek LARC, providing insights for tailored messaging directed at COC users regarding self-identity.

Patiro and Budiyanti (2016) investigated the factors affecting borrowing intentions among young entrepreneurs in the Indonesian TDA community, based on the Theory of Planned Behavior. In this study, self-identity, situational temptation, and past behavior were also considered. A questionnaire was distributed to 200 participants, of which 100 responses were accepted. A 5-point Likert scale was used to collect the data. The data were analyzed using structural equation modeling (SEM) to determine the relationships, and WarpPLS 3 software was used for model analysis. Based on the goodness-of-fit indices (GOF) generated via SEM, it was concluded that the GOF for this research model was quite good. The TPB models developed could effectively

understand, explain, and predict the borrowing intentions of young entrepreneurs in the context of loan applications

Wang and Wang (2015) conducted a study in 2014 to examine the association between TPB variables and moderate-to-vigorous physical activity (MVPA) in children, using the Theory of Planned Behavior (TPB) in Shanghai, China. Gender differences were also explored in this study. Three primary schools were randomly selected from three districts in Shanghai. A questionnaire was prepared and distributed to 561 students, but only 353 were included in the final analysis. The ages of the participating students ranged from 9 to 13 years (M = 11.26, SD = 0.98), with 173 being female students. Physical activity was measured using the ActiGraph GT3X activity monitor over a period of seven days. Subjective norms were assessed using a 7-point scale. Pearson product-moment correlations examined the interrelationships among all TPB variables, while multivariate ANOVA was performed to analyze MVPA in relation to TPB variables. Finally, hierarchical multiple regression analyses were conducted on the TPB variables intended to predict behavior. The results showed that the TPB framework was more effective in explaining physical activity behaviors among boys compared to girls, highlighting important gender differences.

Roy et al. (2020) conducted a study utilizing the Theory of Planned Behavior (TPB) to assess the attitudes, subjective norms, perceived behavioral control, and intentions of adolescents regarding smoking in Gaborone and Francistown, Botswana, in 2014. A sample of 3,000 participants was randomly selected from 75 schools across the two cities. Data entry and analysis were performed using IBM SPSS version 25, employing Chi-Square tests and Logistic regression. The findings revealed that students with positive attitudes toward smoking were more likely to be current smokers, while negative attitudes served as a deterrent. Notably, 80.1% of students who were current smokers acknowledged that they could refuse a cigarette if a friend offered one.

In another study by Boguszewicz-Kreft et al. (2020), the applicability of the TPB in the context of medical tourism was examined, focusing on whether there were differences in predicting the intentions of medical tourists from three countries: Jordan, Poland, and Turkey. A total of 521 young consumers from these countries participated in the study, with questionnaires administered in three languages. The sample comprised 183 respondents from Jordan, 125 from Turkey, and 213 from Poland. All items were measured using a seven-point Likert scale. The data were analyzed using multiple regression and multivariate analysis of variance (MANOVA). The results concluded that the TPB model can indeed be applied to medical tourism, with the country of origin of consumers being a significant factor in predicting their intentions to utilize medical tourism services.

The Theory of Planned Behavior has also been employed to investigate various behaviors, including dairy product consumption among older adults, fertility intentions, anticipated effects, consumer purchase intentions and online shopping behaviors, interaction effects, young adults' intentions to eat healthy foods, and physical activity and health-related behaviors.

Discussion and Future Scope

The review highlights the adaptability and breadth of application of the Theory of Planned Behavior (TPB) explaining human behavior in relation to using public transportation, as well as in exercise, pro-environmental behavior, and purchasing activities. The studies reviewed support that the TPB is an adequate psychological model of intention formation and prediction regarding behavior on the basis of attitude, subjective norms, and perceived behavioral control.

In transportation studies, The TPB has been successfully used to analyze shifts in behavior, including increases in public transport use as well as walking and cycling. It has also been helpful in understanding health behavior, sustainability and consumer behavior. These studies, in fact, reinforce the claims on the versatility of the TPB and the ability to use contextual and topical constructs to increase its applicability in prediction.

Above all, the findings of the Theory of Planned Behavior (TPB) can be used to make decisions by policymakers, urban planners, public health officials, and marketers. For instance – how social perceptions and individual attitudes shape behavior can be applied to encourage social or sustainable behavior through effective

interventions and campaigns. The studies also displayed the usefulness of TPB's extended models which included additional constructs like moral norms, self-identity, and past behaviors, thereby enhancing their explanatory capability. There are a few gaps in the literature that provide ideas for future work. The TPB can be used to analyze behavioral self-regulation and change during global disruptions, such as during the COVID-19 pandemic. There have been drastic changes in the day-to-day life activities, movement, and health-related habits which can be analyzed through the TPB lens to study intention formation under uncertainty or restriction.

Furthermore, combining big data and machine learning allows TPB-based models to operate at larger-than-life scopes—multitude sized scales and in real time. This is particularly important for predictive analytics in transportation systems as it can be used to anticipate changes on travel behavior and plan accordingly. To summarize, the application of the TPB is as strong as the flexibility that it enjoys, especially in the scrutiny of human behavior. Its application and evolution through interdisciplinary approaches and contemporary analytical technologies provides complexities into behavioral phenomena and proffers better innovations across many domains.

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