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Prediction of Citizens' Decisions on Transport Mode Choice in Bandung City, Indonesia by Using General Linear Model Given existing Level of Pedestrian Friendly Environment

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Abstract - Significant contribution of non-motorized transport to energy and environment has changed the view of people on walking or cycling as one of transport modes. While promoting mass rapid transport, modern cities tend to promote pedestrianization as well to encourage people to walk instead of relying on motorized transport. Creating pedestrian friendly environment in particular parts of the city, especially in CBD, is one such attempt. This study tries to investigate the correlation between perceptions of the citizens on pedestrian friendly environment (PFE) and their decision on the choices of transport modes. The central business district of Bandung City in Indonesia was chosen as the study area. A questionnaire-based research was used to acquire data on citizens' perception. Eight variables were employed to understand citizens' perception on PFE. The result shows that PFE does influence citizens' decision on their transport modes choice.

***Keywords*:** pedestrian, decision making, central business district, citizens' perception.

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1. Introduction

Continuous depletion of non-renewable energy sources and degradation of the environment are two palpable issues which persistently threaten mankind. Attempts to conserve them are eventually manifested in various efforts. One attempt is to encourage walking or cycling and, in the same time, discourage motorized transport for walkable distances. Despite their significant roles in the conservation of energy and environment, pedestrians receive less attention. Pedestrians are almost forgotten transportation actors, on one hand, although they are actually group of environmental advocates, on the other. Keegan and O'Mahony (2003) argue that pedestrians have received low levels of priority compared to motorized vehicles. Pedestrian travel is often treated as an afterthought of transport modes and given less consideration than motorized travel modes. Amid receiving low level of priority among transport modes, pedestrians contribute to energy saving and thereby environmental conservation (Wentink, 1980). They indirectly contribute to reduce air pollution created by vehicular trips (Nakamura et al., 2004), and reduce transport energy use as well as emission level (Warren and Enoch, 2006), they also reduce environmental damage (Plaut, 2005). The indirect contribution of pedestrians is mainly on energy saving and pollution control as a result of that contribution. This important role of pedestrians drives many cities to reconsider the promotion of pedestrianization by creating pedestrian friendly environment in particular areas such as central business district.

Central business district (CBD), by definition, refers to the geographical center of a city which traditionally contains concentration of major businesses, service centers and civic activities within a limited area. Traditional CBD differs substantially from their suburban counterparts, primarily in its density of users' activities and their commuting modes. The dense concentration of activity is possible because CBDs are typically accessible by public transportation as well as by car (Voith, 1998). Due to the nature of CBD, which is characterized by "concentration of activity", it becomes a favorable location to place PFE. Moreover, the CBDs are generally identified for pedestrianization more than the others. It is important

to stimulate pedestrian movement to limit the consequences of excessive automobile use in the urban environment. In this respect, knowledge of pedestrian movements is a key factor for better urban planning (Foltete and Piombini, 2007).

Some pertinent studies on pedestrians have been undertaken with different perspectives. Keegan and Mahony (2003), for instance, observed the impacts of signaling on illegal crossing. Sisiopiku and Akin (2003) reported the pedestrians' perception towards various pedestrian facilities. Antonini et al., (2006) demonstrated the characteristics of pedestrians' movement given the presence of other pedestrians. These studies substantiated the important position of pedestrians in the transportation context including impacts created by pedestrians themselves.

Besides the advantages of promoting pedestrians on energy and environment as confirmed by Wentink (1980), Gaffron (2003), Keegan and O'Mahony (2003), Bayley et al. (2004), Nakamura et al. (2004), Plaut (2005), Warren and Enoch (2006), pedestrians are likely impeded by local climate conditions (Newman and Kenworthy, 1999). These two contradictory situations are seemingly hampering the efforts to promote pedestrianization. However, attempts to create PFE shall not actually be hindered by these discouraging and encouraging factors.

The central focus of this study is how pedestrians perceive physical environment of the CBD and reflect their perception in the decision on transport mode choices. The study therefore provides a tool for decision support systems on transport mode choice. For this purpose, the study attempts to explore whether or not PFE will be able to invite more citizens to walk or cycle. It is undertaken by associating citizens' perception on PFE and their decision on walking or using motorized vehicles. This association is quantified and expressed by a multivariate model. The model assigns eight variables as governing variables of the decision of yes or no on walking. There are two types of governing variables considered in the model, namely static and dynamic variables. The static variables constitute adequateness of walkways, number of crossing bridges, number of zebra crossings, quality and functionality of zebra crossings, and adequateness of public utilities. Dynamic variables, on the other hand, include outdoor comfort, street vendors, and over-crowdedness. These variables are believed to influence pedestrians as recent studies support it. These studies are, for example, undertaken by Shriver (1997), Keegan and O'Mahony (2003), Sisiopiku and Akin (2003), Alta Planning and Design Inc. (2004), Parks and Schofer (2006), and Antonini et al. (2006). CBD in Bandung City has also been chosen because of its unique condition of PFE. This uniqueness is particularly due to inadequateness of most of the static variables components, while overwhelmed of the components of dynamic variables.

2. Present Conditions of CBD in the Study Area

Bandung City is the capital city of the West Java Province of Indonesia. The present area of Bandung City is 16,767 hectares. A general map of Bandung City is shown in Figure 1. Central business district of Bandung is located around the geographical center of the city. It constitutes about 225 hectares with mixed land use but mostly commercial areas, as shown in Figure 2.

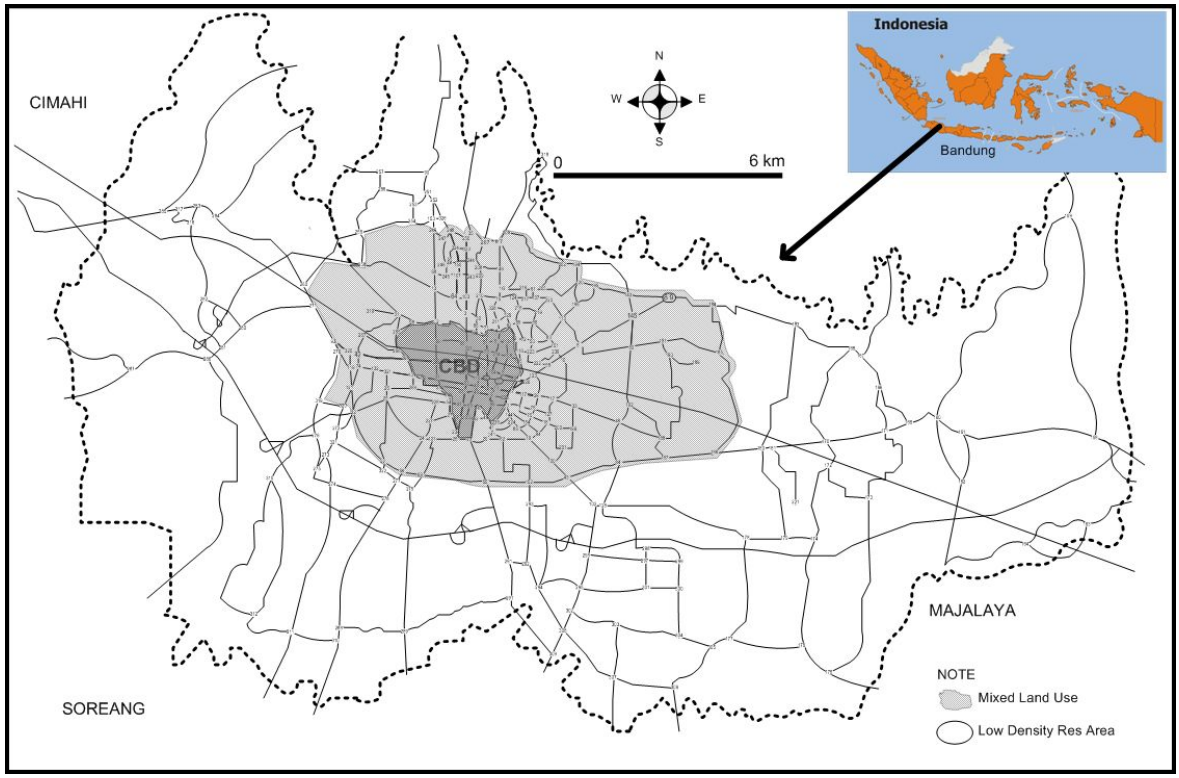

Figure 1. General Map of Bandung City

Present CBD was the embryo of the city during the Dutch Colonial period in 1900s where *Pendopo*, the Office of the Head of Bandung District, was constructed. The ancient CBD was usually featured by the *Alun-alun* square in front of the *Pendopo* building. The great mosque was placed at the west-end of *Alun-alun*, and diametrically *Pendopo* was placed at the east-end. The *Alun-alun*, was therefore flanked by the great mosque and *Pendopo*. The *Alun-alun*, which literally means green open space, had primeval function of gathering during the ancient royal ceremonies. The common feature of ancient CBD was found in many secondary cities of Indonesia such as Bandung, Bandaaceh, Banten, Medan, Palembang, Surabaya, Surakarta, Yogyakarta etc. The feature influences the urban land use up until present days. Land use of Bandung City follows concentric pattern with mixed use in the center and low residential density in the periphery. The concentric pattern is also augmented by developers-driven urban sprawling, which has also created immense number of commuters (Permana, 2005). The process has led to inefficient use of energy as private vehicles is the predominant mode of transport in the city. The absence of good and efficient public transport has also contributed to such inefficiency.

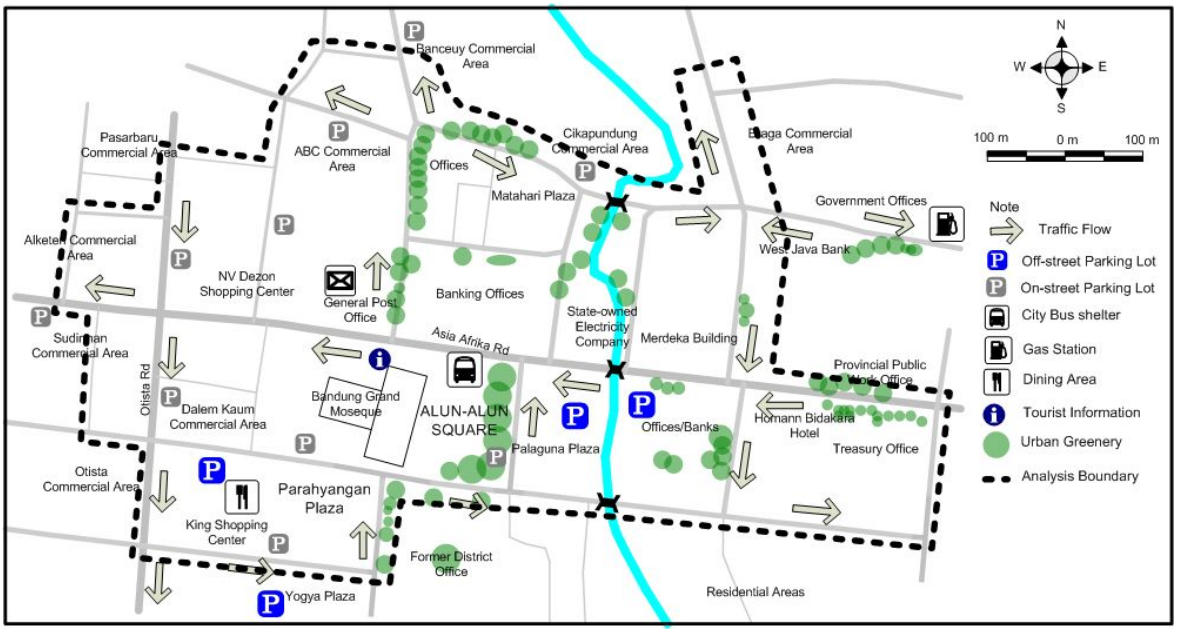

Figure 2. CBD: Boundary of the Analysis

The absence of good public transport and non-proximity of origin-destination for jobs and also inexpensive motorcycles have forcefully or voluntarily driven people toward motorized transport dependence. Motorcycles are presently seen as a better alternative to any other public transport available in the city. With current state of ubiquitous congestion in Bandung City, motorcycles are even considered as having better maneuverability than cars and more cost-efficient than private cars and taxis with a comparable comfort. Numerous approaches have been undertaken to push more motorized transport independent citizens. One of them is creating pedestrian friendly environment to discourage citizens using motorized private transport which is actually unnecessary.

TSC (2004) noted that one new approach to appealingly persuade people to walk is smart growth. It is also acknowledged that smart growth attempts to optimize trilateral facet of development: social, economic and environment entities. By this philosophy, balance between the needs of pedestrians and motorists are required. The balance does not necessarily mean that the needs of both are quantitatively equal rather maintaining the proportion of both in an appropriate extent. Promoting one side shall not sacrifice the needs of other side. However, in most cases the needs of motorists have so far been entertained at the costs of pedestrians.

Unlike their counterpart in the cities of developing countries, cities in developed countries have tried to deeply consider and progressively apply policies and plans on pedestrians. Southworth (2005) noted that pedestrian and bicycle policies and plans have been developed as it was addressed by Transportation Equity Act for the 21st century (TEA-21). It was because walking and bicycling were viewed as essential ingredients of an integrated inter-modal transportation system which gave travelers transportation options and provided connection from origin to destination. In the same tone, Chauncey and Wilkinson (2003) stated that pedestrian and bicycle needs were considered in transportation planning at all scales in California. Those efforts have inspired the needs of similar model in developing countries with different approaches. One of the approaches is by developing a multivariate model which involves various governing variables on the choice of the users.

3. The Selection of Eight Governing Variables

Some studies have attempted to understand the correlation between transport mode choices and urban environment (Crane, 2000; Badoe and Miller, 2000). It has also been affirmed that urban physical environment, urban characteristics and transport mode choices are correlated. Clifton et al. (2006) acknowledged the direction and magnitude of the relationships between

land use characteristics and the quantity of travel by various modes. These studies show the importance of pedestrian choices on transport modes which can be affected by the perception on PFE.

Despite the environment, culture has been partially believed to having coercive force on walking citizens and travel behavior. However, Næss (2004) argued that many of the early empirical studies which demonstrate the correlations between urban structure and travel behavior were criticized for not taking into consideration socioeconomic factors and disregarding the influence of the travelers' attitudes and lifestyles. There is a risk that differences in the transportation pattern actually caused by socioeconomic factors, however, for the manageability purpose, it is assumed that socioeconomic factors including culture are adherently reflected in the proposed governing variables of multivariate model of PFE.

The selection of governing variables was based on the pre-assessment of the citizens' most required facilities at the central business district in the study area. In this process, two-stage survey has been carried out. In the first stage, randomly selected respondents were asked their opinion on what kind of PFE facilities do they require and other aspects which possibly encourage or discourage them to walk. A guided question on PFE was given to ensure that they were familiar with PFE facilities including their functions. First stage survey has resulted in the proposal of eight variables. The type of PFE facilities which were resulted from first stage survey were incorporated into second stage survey. In the second stage, a structured interview with randomly selected respondents was undertaken to acquire their perception on PFE.

The selection of eight variables was also supported by recent studies pertaining to pedestrian friendly environment. Study undertaken by Shriver (1997) identified that spatial and environmental characteristics influence pedestrians. While Alta Planning and Design Inc., (2004) acknowledged that the adequateness of sidewalks, curb ramps, pedestrian crossings, shorten crossings, signs and signals influence pedestrian behavior. Keegan and O'Mahony (2003), on the other hand, demonstrated that pleasantness of the environment and shorter waiting time in a traffic signal affects the pedestrians. Parks and Schofer (2006) argued that pedestrians' activities were affected by characteristics of individuals and households, neighborhood density, design, mixed land use, social environment, cultural norms, safety and security. Sisiopiku and Akin (2003) stated that pedestrian's behavior was affected by the conditions of signalized and unsignalized intersection crosswalks, unsignalized marked and non-striped midblock crosswalks, physical barriers, midblock crosswalk shelters, colored paving at medians and curbs, and pedestrian warning signs. Antonini et al. (2006) identified that safety-related immediate environment influences walking behavior of the pedestrians.

Above studies explicitly support all of the static variables selected in the present study. However, the variables of street vendor and over-crowdedness are not supported by the above studies in an explicit manner. It is understood since the studies were carried out in developed countries, while street vendor and over-crowdedness are the issues of developing countries. Moreover, studies on pedestrian friendly environment are rarely carried out in the cities of developing countries. Despite unsupported, street vendor and over-crowdedness are included in the analysis to accommodate perception of the citizens.

Observations were undertaken at a closed system (a control volume) as depicted in Figure 2. The only respondents within this system were interviewed regarding their perception on PFE in the designated control volume. To provide general picture of the PFE facilities, present conditions of the governing variables along with PFE within the control volume are described below. The governing variables consist of static variables and dynamic variables.

i. Static Variables

Static governing variables consist of some selected facilities of pedestrian friendly environment which are characterized by stationary and invariable position in a relatively long time.

Adequateness of walkways. From the first stage survey, it seems that shaded walkways are the most preferred PFE component. Presently, there is only few meter of walkways in Bandung City are shaded. The most usual walkways (bikeways excluded) are 1.5 meter wide unshaded walkways, but most of the walkways are 'illegally' occupied by street vendors. This condition hinders pedestrians to walkthrough the CBD and reduces comfort.

Number of crossing bridges. There are only two overpass crossing bridges. One of them is presently vacant and left unutilized due to frequent crime incidents. Another crossing bridge is totally uncomforting for being used by the pedestrians.

Number of zebra crossings. Presently zebra-crossings are not equipped with adequate signaling for better safety of the pedestrians. This facility is not respected by most of the drivers. It causes the zebra crossings leave unutilized. Number of zebra crossings at the time of survey was six which totally inadequate to safely facilitate the pedestrians.

Quality and functionality of zebra crossings. Poor maintenance of the zebra crossings has led to lower quality and functionality of them. Thereby, the presence and function of zebra crossings are not at all respected by the motorists and accordingly ignored by the pedestrians.

Adequacy of Public utilities. Comfortable and adequate public spaces do not exist to be accessed by the citizens. Presently, development of parks in front of the great mosque is undergoing, however due to financial problems, the development will seemingly never end. The only few public telephone booths are functioning at some points. Public benches and children playground are not available. Public drinking water taps are also not available

since it is not quite common with the city authority in Indonesia to provide public drinking water taps.

ii. Dynamic Variables

Dynamic variables are all governing factors which dynamically change over time and space. They do not inert physical facilities as static variables do. These variables are included in the analysis since the multivariate model is multi-dimension in nature. Thereby all aspects those perceived by the citizens in possibly having influence on their decisions are eligible to include.

Outdoor comfort. Stale, noisy, dusty, too hot or too cold outdoor environment would affect the citizens' decision to walk. Outdoor comfort variable was perceived by the respondent to have direct influence on their decision to walk. The current level of air quality, noise and congestion at the CBD are poor (EIMA, 2003 and Permana, 2005).

Street vendors. Street vendors and on-street parking are two factors which bring a dilemma. On one hand, their availability is needed by citizens because of the easiness they offer. On the other hand, their existence is quite irritating. Citizens need street vendors as they provided cheaper goods with reasonable quality than formal shops. While, on-street parking is the most convenient for most of the motorists since they could stop and park wherever they need it. However, both create congestion as well as inconvenience for most of the pedestrians.

Over-crowdedness. Despite its discouraging environment, the CBD invites citizens and frequent visitors from outside of the city, particularly during the weekend. Over-crowdedness has been daily scenery of the CBD. Over-crowdedness may invite pick-pocket and it is obviously unpleasant incident for the pedestrians.

Although there are still some possible variables to be included in the analysis, but again for the purposes of manageability, the only above governing variables are considered. Further discussions on the analysis are given in the following section.

4. Multivariate Correlation between Pedestrians and Environment of the CBD

The establishment of a multivariate model based on perceptions of the citizens on pedestrian friendly environment is discussed. To establish the model, the citizens' perceptions on PFE are quantified, and PFE is reflected in the eight governing variables.

Interest in improving pedestrians' environment has grown as a result of the desire to encourage non-motorized travel to reduce vehicle-miles and pollution emissions, and more recently to improve public health by means of increased physical activity in the form of walking (Parks and Schofer, 2006). Jian et al. (2005) added that pedestrian movement is an important component in the analysis and design of transportation facilities, pedestrian walkways, traffic intersections, markets, and other public buildings. They argued that random flow of pedestrians is considered as an essential ingredient. Studies of the flow of large pedestrian crowds associated with special events are limited when compared with those of pedestrian flow in normal walking environment. In large crowds, there is a potential for injury and even loss of life resulting from the dynamics of the crowd's behavior (Lee and Hughes, 2006). The complexity of pedestrian behavior comes from the presence of collective behavioral patterns evolving from the interactions among a large number of individuals. This empirical evidence leads to consider two different approaches; pedestrians as a flow and pedestrians as a set of individuals or agents (Antonini et al., 2006). These studies confirm that pedestrians are essential actors who closely associated with immediate physical environment.

It is likely true that the locations of both actual and perceived pedestrian risk depend on a combination of physical environment (what many people perceived as pedestrian friendly environment), as well as, individual factors. Physical environment factors include the presence of sidewalks, traffic, and roadway crossings. While, individual factors include the ability to judge distance and speed, visual capabilities, and the physical ability to move quickly and change direction (Schneider et al., 2004). Some of them, as previously discussed, enact as governing variables. All these variables are acquired from the respondents, as she/he perceives. This is purely anthropogenic behavior approach that governs people's activities. The activities will commonly require movement from one place to another. When motorized transport means are used, transport energy is then required. Contribution of non-motorized transport to total transport modes in Bandung City is presently negligible. In the same time, the use of private transport, especially motorcycle, has been growing significantly during the last few years. This is because of the easiness of having a motorcycle. With only USD 50, citizen may bring home a motorcycle in a relatively affordable monthly payback scheme. This issue can be considered as an encouraging factor of motorized transport dependency of the citizens which may lead to adverse consequences on energy use and environment conservation. This study is expected to contribute towards energy and environment conservation by way of creating pedestrian friendly environment to minimize motorized transport dependency. Creating PFE requires comprehension on their governing variables. This study provides such cognition.

The study was undertaken at the CBD within the boundary of study area (as shown in Figure 2) by undertaking structured interview with randomly selected visitors of CBD during weekend at 9:00am to 15:00pm. The selected visitors included those traveling with vehicles. For this kind of visitor, a glance interview was undertaken. The weekend was selected since more varied visitors come and the numbers of visitors were usually higher than weekdays. Fifty-seven randomly selected respondents were interviewed. Very brief questions were asked to avoid rebuttal from the respondents. The only direct governing variables were asked, while income and vehicles ownerships were not asked. This evidence was supported by citizen's perception on pedestrian friendly environment as shown in Table 1.

Table 1. Citizen's Perception on Pedestrian Friendly Environment

No	Description	Count
	Number of respondents (interviewees)	**57**
A	**Variables Explored**	
	Static Governing Variables	
1	About walkway (particularly in city center, CBD):	41
	• Extremely insufficient	10
	• Insufficient	6
	• Neither insufficient nor sufficient	0
	• Sufficient	0
	• Extremely sufficient	
2	About number of crossing bridge:	
	• Extremely insufficient	50
	• Insufficient	1
	• Neither insufficient nor sufficient	6
	• Sufficient	0
	• Extremely sufficient	0
3	About number of zebra cross:	
	• Extremely insufficient	0
	• Insufficient	48
	• Neither insufficient nor sufficient	3
	• Sufficient	6
	• Extremely sufficient	0
4	About quality and functionality of zebra cross:	0
	• Very good	0
	• Good	6
	• Neither good nor bad	16
	• Bad	35
	• Very bad	
5	Public utilities/facilities (toilet, tap water, public phone, police booth, information):	
	• Extremely insufficient	38
	• Insufficient	13
	• Neither insufficient nor sufficient	6
	• Sufficient	0
	• Extremely sufficient	0
	Dynamic Governing Variables	
6	About outdoor comfort (greenery, shaded walkway, air quality):	0
	• Very good	0
	• Good	7
	• Neither good nor bad	16
	• Bad	34
	• Very bad	
7	Street vendors:	
	• Extremely irritating	21
	• Irritating	24
	• Neither irritating nor appealing	5
	• Appealing	4
	• Extremely appealing	3
8	Over-crowdedness:	
	• Very bad	43
	• Bad	7
	• Neutral	7
B	**Decision taken by the interviewees**	
	• **Walking**	**6**
	• **Using vehicle**	**51**

Most of the interviewees articulate negative perception on the quality, functionality and quantity of the pedestrian-friendly facilities. The interviewees were asked about the crossing-bridge, majority of the interviewees perceived that number of crossing-bridges were extremely insufficient. A question on comfort of the outdoor environment such as the availability of shaded walkways, urban greenery and air quality was also asked. Most of the interviewees perceive that urban outdoor comfort was a luxury in the city, since 50 out of 57 interviewees chosen "bad" in responding on this issue. No single respondent perceives urban outdoor comfort as "good". Other aspects have similar responses from the interviewees that lead to the absence of pedestrian friendly environment. This outcome will advance to the augmentation of motorized travel for even walking distance.

Decision in the last row in the Table 1 shows citizens' perception, based on what they perceived on pedestrian friendly environment, on whether they wish to take a walk within central business district or use vehicles (private cars, motorcycles or public transports). It is not so surprising when citizens perceived that they prefer to use vehicles instead of walking. Based on data acquired from the interview with all respondents, a multivariate analysis to predict citizen's decision on whether walking or using vehicles was established. Despites few variables to be acquired from the survey, this model can be used to forecast correlation between pedestrian friendly environment and "walking community". Thereby the question of "Can pedestrian friendly environment affect citizens' decision in transport modes choices?" most likely be answered.

As it has been discussed earlier, the analysis is based on eight independent variables. Since most of the answers are qualitative in nature, hence a quantification process is undertaken to enumerate the qualities. The quantification procedure is undertaken as the followings:

- **Walkways**. It is measured by discretely scaling -2 (extremely insufficient), -1 (insufficient), 0 (neither insufficient nor sufficient), +1 (sufficient) and +2 (extremely sufficient). It is assigned as variable X_1;
- **Number of crossing bridges**. Similar scaling system with walkway variable is applied. It is assigned as variable X_2;
- **Number of zebra crossings**. The same as above two variables, and it is assigned as variable X_3;
- **Quality and functionality of zebra crossings**. This variable is discretely scaled with -2 (very bad), -1 (bad), 0 (neither bad nor good), +1 (good) and +2 (very good). It is assigned as variable X_4;
- **Public utilities**. Scaling of this variable follows -2 (extremely insufficient), -1 (insufficient), 0 (neither insufficient nor sufficient), +1 (sufficient) and +2 (extremely sufficient). It is assigned as variable X_5;
- **Outdoor comfort**. This variable is scaled in similar manner with quality and functionality of zebra crossing variable. The variable is assigned as variable X_6;
- **Street vendors**. To certain extent this variable either irritates or attracts the walkers. Because of this matter, this variable is included. The scaling system adopts -2 (extremely irritating), -1 (irritating), 0 (neither irritating nor appealing), +1 (appealing) and +2 (extremely appealing). The variable is assigned as X_7;
- **Over-crowdedness**. This factor prevents citizens to walk, that is its relation. Differ with other variables, this variable is scaled with -2 (very bad), -1 (bad) and 0 (neutral). No positive scale for this variable since no positive answer will be attained. This variable is assigned as X_8.

These eight variables are expected to derive the citizen's decision on walking or otherwise. Citizen's

decision is dummied by proposing +1 for the decision for walking and -1 for taking decision for using vehicles. All interviewees' responses are dummied into a quantifiable value as explained above. The analysis results in the establishment of following multivariate correlation:

$$y = 0.13048\ X_1 + 0.44793\ X_2 + 0.67086\ X_3 + 0.26096\ X_4 + 0.00000\ X_5 - 0.32679\ X_6 + 0.10035\ X_7 - 0.43112\ X_8 \quad (1)$$

The decision of the citizens (y) shall be definitely an integer number which is either +1 or -1, while right hand side of the equation will give in a real number. The correlation is also very sensitive. Thereby it is possible to yield figures larger than +1 or less than -1. For this situation, the figures are conditionally assigned to +1 and -1. Therefore, assignment for out-of-range and non-integer figures is undertaken as follows: if y>0 the decision is equal to +1, it means citizens theoretically tend to walk in the CBD providing their perception on PFE. If y=0 the decision is neutral, depending on immediate condition, citizens will either walk or use vehicles. If y<0 the decision is equal to -1, it means citizens will use vehicles to accomplish their travel within the CBD. If decision of the citizens returns 0 or neutral value, the improvement of PFE facilities that have significant influence on the citizens' decision shall be attended. The approximation toward integer number is taken as the rounding-up of the real number and taking its integer as following statement:

$$Decision = integer\ [roundup(y)] \quad (2)$$

Above correlation has the characteristics of coefficient of determination $(r^2) = 0.97891$ and standard error = 0.15663. The analysis of variance (ANOVA) is shown in Table 2

Table 2 Analysis of Variance Properties (Confidence level: 95%)

Component	Degree of Freedom	Sum of Square	Mean Square	F	Significance F
Regression	8	55.79787	6.97473	284.2981	1.0172E-37
Residual	49	1.20212	0.02453		
Total	57	57			

With the coefficient of determination of 0.97981 of the correlation seems adequate to explain the citizen's decision on their choice to walk or use vehicles considering particular condition of the PFE. Evaluation on the individual variable on their contribution towards the decision is shown in Table 3. However, care must be taken when multivariate correlation is used. This correlation is noticeably valid for only certain condition with definite location. Similar process can be undertaken to establish analogous multivariate correlation at the places with similar characteristics of the citizens.

Table 3. Statistical Properties of the Equation

Variable	Coefficient	Standard Error	t-statistics	t-critical	Verbal Explanation
Intercept	0	NA	NA	0.481 for degree of freedom 8, for 95% confidence interval	NA
X_1	0.13048	0.13467	0.96884		Statistically significant
X_2	0.44793	0.07028	6.37311		Statistically significant
X_3	0.67086	0.08161	8.21992		Statistically significant
X_4	0.26096	0.15325	1.70282		Statistically significant
X_5	7.9E-17	0.12788	6.2E-16		Statistically significant
X_6	-0.32679	0.12930	-2.52725		Statistically insignificant
X_7	0.10035	0.04495	2.23241		Statistically significant
X_8	-0.43112	0.11247	-3.83535		Statistically significant

Seven out of eight variables are predicted to contribute significantly to the decision. Although variable of public utilities (X_5) has no effect to the decision because of its negligible value i.e. 7.9E-17. Two variables, outdoor comfort and over-crowdedness have negative impact to the decision. It means that if those variables increase in quantity citizens will respond negatively. In other words, if outdoor comfort and over-crowdedness worsen and perceived badly by the citizens, the citizens tend to use vehicles to travel within the CBD. Table 4 shows the extent of correlation among governing variables. It shows consistent responses received from the respondents on current pedestrian friendly environment since the correlation among governing variables shows reasonably high coefficients. All coefficients of correlation are greater than 0.7. The clarity of the issues has made possible of such consistency.

Sensitivity analysis is undertaken by hypothetically assigning responses of the citizens. It is necessary to understand on which variables those have great impacts on the citizens' decision for the same degree of citizens' responses. It is also essential for the urban planners to designate certain higher priority PFE facilities to affect citizens' decision, by undertaking only minimum efforts. Illustration on different condition on those eight variables toward the decision is given by assigning -2, -1, 0, +1 and +2 for all variables and other combination of the responses. The results are given in table 5.

Table 4 Correlation among Governing Variables

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	1.000	--	--	--	--	--	--	--
X_2	0.843	1.000	--	--	--	--	--	--
X_3	0.875	0.957	1.000	--	--	--	--	--
X_4	0.896	0.774	0.798	1.000	--	--	--	--
X_5	0.873	0.768	0.788	0.965	1.000	--	--	--
X_6	0.945	0.806	0.834	0.946	0.917	1.000	--	--
X_7	0.873	0.815	0.846	0.858	0.872	0.863	1.000	--
X_8	0.944	0.865	0.896	0.848	0.864	0.893	0.891	1.000

Table 5. Hypothetical Citizens' Decision on Various Pedestrian Friendly Conditions

Walkway	# of Crossing Bridge	# of Zebra Cross	Quality & Functionality of Zebra Cross	Outdoor Comfort	Public Utilities	Street Vendor	Overcrowd	Decision
-2	-2	-2	-2	-2	-2	-2	-2	Vehicles
-1	-1	-1	-1	-1	-1	-1	-1	Vehicles
0	0	0	0	0	0	0	0	Neutral
+1	+1	+1	+1	+1	+1	+1	+1	Walking
+2	+2	+2	+2	+2	+2	+2	+2	Walking
0	0	0	+2	0	0	0	0	Walking
+1	+1	0	0	0	0	0	0	Walking
0	+2	0	0	0	0	0	0	Walking

Note: a quantified perception has been used to quantify interviewees' responses, such as 2 (extremely insufficient), -1 (insufficient), 0 (neither insufficient nor sufficient), +1 (sufficient) and +2 (extremely sufficient); or -2 (very bad), -1 (bad), 0 (neither bad nor good), +1 (good) and +2 (very good); or -2 (extremely irritating), -1 (irritating), 0 (neither irritating nor appealing), +1 (appealing) and +2 (extremely appealing), depending on the context of the inquiry.

The analysis shows that, if all the variables are bad or extremely bad (-1 or -2), citizens tend to refrain from walking. On the other hand, if citizens perceived that all variables of the pedestrian friendly environment are good, citizens tend to walk. Similarly, it appears if quality and functionality of zebra crossing is perceived as excellent by the citizens. Contradictory, excellent walkways cannot guarantee to significantly manipulate citizens' decision. Combination of sufficient walkways and crossing bridge will seemly encourage citizens to walk. In reality, the perception on those variables will not be uniform.

What does it imply to the urban planning and urban energy consumption? If and only if, citizens perceive, at least, all variables of the pedestrian friendly environment are good, they will possibly decide to accomplish walking within particular distance in the domain of central business district instead of using vehicle. Thereby no motorized travel will be accomplished by the citizens. Moreover, no energy will be consumed. Creating pedestrian friendly environment, to some extent will save energy and conserve environment. Quality and functionality of the zebra crossing shall be given first priority to achieve excellent perception of the citizens to encourage them to walk. This is a minimalist approach considering present financial capability of the Bandung City authority.

"Willingness" to voluntarily walk instead of using vehicle of the citizens is governed by various factors. It is essential to understand the distance of which the citizens are willing to walk. The comprehensive understanding on this particular issue may drive the unnecessary motorized trip turns into walking. Heavily depending on the motorized transport for just accomplishing few meters may lead to also health problems such as obesity as confirmed by Bell et al. (2002). They stated that obesity cases were eighty percent higher for men and women in households who owned motor vehicles compared with those who did not own vehicle. This case shows the importance of walking-minded community.

One of the respondents' reasons to walk is comfortable and enjoyable urban environment. This reason is again subjective and qualitative reasoning. Clustered survey in Bandung City on willingness to walk is referred to current urban environmental condition. The distance is therefore expected to increase whenever more comfortable and enjoyable urban environment is created, but unfortunately there is no appropriate comparison in similar city particularly in Indonesia to validate such expectation.

5. Possible Strategies Towards Creating PFE

The establishment of multivariate model provides a tool of decision support systems which is simple but powerful to predict citizens' decision on transport mode choices. Multivariate correlation discloses very clear messages for urban planners on what to be done to encourage citizens to walk. Variety of strategies shall be

carried out to improve pedestrian safety at crossings. These include signs, road painting and hump to encourage drivers to stop or traffic calming for pedestrians (Nasar, 2003); extensive local media campaigns (Koenig & Wu, 1994), provision of adequate pedestrian signage, traffic calming; pedestrian weather protection (City of Vancouver, 1993). The most important part in encouraging citizens to walk within the CBD of Bandung City, is the construction of all facilities those required to sufficiently entertain pedestrians.

Harre and Wrapson (2004) suggested that to serve pedestrians while protecting their safety, campaign that used visual images and messaging at the intersection in the CBD is required. This activity shall be accompanied by reward and punishment systems. These are intended to (a) encourage pedestrians to use the crossing and cross on the green rather than the red light (b) encourage drivers turning left to give way to pedestrians. The full campaign ran for seven weeks to coincide with the peak months for pedestrian injuries.

Local culture and wisdom shall be deeply considered whenever pedestrian friendly environment is promoted in the central business district. In case of study area, since most of the citizens are fond of socializing themselves by making informal conversation with other citizens disregarding they have previously knowing each other. Study area is a city in tropical country with abundant rainfall and sunlight, shady environment and shaded walkways are, thereby, required. However, the development of such facilities shall be accompanied by a campaign to improve the sense of belonging of all citizens. This is to avoid possible damage of the facilities due to vandalism. The possibility of being occupied by hawkers shall also be assessed, since street vendors and hawkers are two factors which, most of the time, impede citizens to walk. Although a fact shows that despite irritating some citizens pinpoint that they also offer inexpensive goods which attract a lot of citizens to come and bargain.

6. Conclusions

Multivariate analysis on respondents' reaction upon structured interview in the central business district in Bandung City Indonesia discloses that pedestrian friendly environment with satisfactory pedestrian facilities is capable to encourage citizens to walk rather than to use vehicles. This is an essential input for the urban planners to redevelop and refurbish the central business district towards more pleasing environment and saving urban energy. The efforts are not necessarily carried out at the only central business district. Other places are also possible as long as potential pedestrians are there. Different strategies can also be applied to encourage citizens to walk, however pleasing physical environment for pedestrians are the most attracting factors. Local climate shall also come into consideration.

The multivariate correlation resulted cannot be generalized and shall be applied with careful consideration. For different characters of the citizens, it is recommended that data acquisition to establish similar correlation shall be carried out with similar process. Despite simple, the correlation can be a powerful tool to predict citizens' decision on the choice of transport modes.

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