Formative Indicators Testing on Model Prediction for Association Perception of Walkability, Walk Preferences, and Walking Behavior Beliefs with Access Mode Choice for Using Train: Indonesia Case

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Abstract: This study aimed to examine the relationship between the perception of walkability (PW), residential self-selection (walk preferences - WP), and walking behavior beliefs (BB) with an access mode choice (AM) for using train for case Indonesia (residents around Cicalengka station). In view of the relationship is done by testing formative indicators for all variables. Given the latent variable with formative indicators that make up that constructs, then the SEM-PLS is used for analysis. From the analysis of 11 formative indicators for the 3 constructs, 7 indicators are significant. They are distance, safety from traffic, safety from crime (PW); leassure walking (WP); walking is health, and cheap (BB). Sidewalk, accessibility, walking is fun, and practice are not significant. PW causal relationship with AM, WP, and BB is also weak. In relative terms, the moderator variables that have interaction with PW in its relationship with AM is gender.

Keywords: formative indicator, perception of walkability, residential self-selection, travel attitude, access mode choice

1. INTRODUCTION

Correlation between built environment and travel behavior had been discussed with many research perspectives, included the one that related to access mode choice for the use of public transportation. Built environment also known ad of the factors that affect the use of public transportation (Ryan & Frank, 2009). In this case, built environment has been categorized as a pedestrian environment. Among the characteristics of the built environment are most often found to influence the use of public transport is walking distance from or towards public transportation (Daniels & Mulley, 2013; Ratanawaraha, et al., 2015). Not only had the distance related to the use of public transport services, but also the overall accessibility to the public transportation. (Wibowo & Olszewski, 2005; Hess, 2009). Park, et al. (2015) even using the various attributes of urban design for measuring the walkability that will affect people's decision to run to the railway station or not.

Although many researchs that prove empirically there is a significant correlation between the built environments with the travel behavior, is still perceived vagueness of the

correlation. There are other empirical studies that prove that the built environment does not always cause people to want to walking, cycling and using public transport. There is a mismatched between mode choice and spatial perceptions (Van Acker, et al., 2013), because of it's influenced by the perception of its residence's type. There is also a mismatched between a commuter's current neighborhood type and their preferences regarding physical attributes of the residential neighborhood (Schwanen & Mokhtarian, 2005). Specifically, there is a study that found an association between the perceptions of the built environment with walking (Nathan et al., 2014).

The correlation between built environment and travel behavior also debated by others researchers. Also there are correlations between built environment and walking behavior does not mean the change of built environment also change directly travel behavior because of there is a correlation with self-selection (Handy et al., 2006). Dill et. al. (2014) states that psychological theory can improve walking and cycling, is how attitudes, social norms, and perceived behavioral control into mediation when the built environment affects people for walking or biking. Cao et al. (2009) I reviewed about empirical finding about the impacts of residential self-selection on travel behavior, with a variety of variables and methods used. The results of a review of the empirical study found that the influence of the built environment and self-selection on the variety of the travel behavior.

2. ISSUES AND PREVIOUS STUDIES

The purpose of this study is to examine the influence of built environment on the access mode choice for train using. So, the choice of access mode (AM) will be the dependent variable, while the built environment is the independent variable. The train users,the respondence, live not far from Cicalengka train station, Regency of Bandung, Jawa Barat, Indonesia, and also part of Bandung Metropolitan Area.

As most of the middle to lower society in Indonesia, the population around Cicalengka railway station, many of them have a motorcycle. Moreover, in Indonesia there are public transportation for short distances and being in the form of paratransit (in the form of SUVs that have formal operating permits) and 'ojek' (in the form of motorcycles that do not have operating permits as public transport). Therefore, train users who live in the vicinity of Cicalengka station have four options for access modes, such as walking, paratransit, ojeg (motorcycle taxi), or private motorcycle.

Before the scope of research is described, there are two issues background of this research. First, it's about how to measure the built environment that influence on travel behavior. Second, the self-selection or attitudes need to be included in analyzing the influence of the built environment on the travel behavior.

Built environment in this study is presented as walkability. Walkability measurement methods vary, and can be distinguished by its data. Among these are based on the scale and tools used to obtain data. Given scale, walkability can be measured in macro / messo, as is done by Cervero et al. (2009), the urban form attributes, such as density, land use mix, street patterns, destination accessibility and distance to transit. Tools that used are the specific indicators, so data on the macro level measurement / meso is obtained objectively and can use GIS. For any micro-scale, the data can also be obtained walkability objectively by using the features of urban design, as practiced by Alfonzo et al. (2008) and Park et al. (2015). Meanwhile, measurements of subjectively walkability can be done on a micro and meso scale, as a study conducted by Nathan et al. (2014). Objective and subjective approach can also be used with a specific purpose, such as in research Handy et al. (2006).

From the findings of previous studies, it seems the influence subjectively measuring

walkability relative more significant on the travel behavior. Therefore, in this study, perception of walkability (PW) is an independent variable that will be analyzed on the influence the choice of access mode (AM) by the train which departs from Cicalengka station.

However, the correlation between PW on AM, as the finding of previous studies (Cao et al., 2009; Handy et al., 2006; and Dill et. al., 2014), there is a self-selection factor or an attitude. Therefore, in this study considered moderating variables included self-selection and attitude. This variable can be categorized as Walk Preferences (WP) which is the preference of the walk when choosing a place to stay and Behavior Beliefs (BB), which is a belief about walking.

Almost in all studies about the correlation of built environment with travel behavior, one of the important variables is socio-demography, which has big influence of travel behavior. Usually, the characteristic of socio-demography that considered is gender, age, and vehicle ownership. For many empirical studies that have been done, usually the vehicle ownership that has been analyzed is car ownership. Different with those cases, in this study, vehicle ownership train users that lived in the vicinity of Cicalengka station more have motorcycles.

Table 1. Some of Previous Research on the Correlation of Built Environment with Travel Behavior

Source	**Travel Behavior Measurements**	**Sample**	**Built Environment Measurement**	**Consider Attitude of Travel**	**Consider Residential Self-Selection**	**Socio-Demographic Characteristics**
Walton & Sunseri, 2010	Mode choice: Access mode for using train and bus – drive or walk	Transit and park-and-ride users	Subjective	Yes	No	Gender, age, income
Handy, et al., 2006	Frequency of walking and biking Trip purposes: to store and strolling arround neighborhood, and others	Residents in traditional and suburban neighborhoods	Subjective and objective	Yes	Yes	Age, gender, occupation, education level, household size, etc.
Nathan, et al., 2014	Frequency and duration walking Trip purposes: exercise, leisure, and transport	Retirement villa residents	Subjective	No	Yes	Age, sex, education level, and others
Dill, et al., 2014	Bicycling or walking frequency	Residents in less connected and good connected residential neighborhood	Objective	Yes	No	Age, education, vehicles, gender
Schwanen & Mokhtarian, 2005	Mode choice: Commute	Urbanites and suburbanites	Objective	Yes	Yes	Age, gender, and others
Cao et al., 2006	Walking frequency The purpose of the trip - Strolling and walking to store	Residents in traditional, early-modern, and late-modern neighborhoods	Objective and subjective	No	Yes	Gender, long settled, vehicle ownership, size of houshold, income
Cao & Fan, 2012	Personal miles travelled, driving duration, and transit duration,	Residents in high and low density	Objective	No	Yes	Gender, age, size of household, vehicle ownership, and others

Source	Travel Behavior Measurements	Sample	Built Environment Measurement	Consider Attitude of Travel	Consider Residential Self-Selection	Socio-Demographic Characteristics
Sanit et al., 2014	Mode choice	Residents in urban	Objective	Yes	Yes	Sex, size of household, car ownership

Based on the issues about the measurement varieties to built environment and its influence to the travel behavior. The purpose of this study is to predict the correlations between perception of walkability, walk preferences, walking behavior beliefs, and access mode choice, with some formative indicators.

3. METHODOLOGY

The Users of Bandung Raya Local trains departing from Cicalengka railway station is the goal of this study. However, the train user will be selected as the respondent only they who have ratings distance from home to the train station can be reached by walking. Of the 214 survey respondents who do, only 135 set of data that can be processed because the other is not complete.

From previous research, there is the influence of self-selection and attitude on the travel behavior, but there is no standard pattern of correlations. Cao, et al., (2009) identified four potential correlations between the built environment, self-selection, and travel behavior. Various methods were used to analyze the correlation between the built environment with the travel behavior, including instrumental regression, propensity score matching, structural equation modeling, and much more. However, Cao et al. (2009) recommends using longitudinal structural equation modeling with control groups because this design is strong with respect to all association form.

In this study, the method used is structural equations based model variants, the SEM-PLS. The consideration is that, first, the model developed, in addition to involving latent variables, as well as a mediator variables and moderator variables.

Which becomes the dependent variable is the access mode choice for using train, which is the mode that is used from home to the station (AM). Based on preliminary studies, there are four access modes used by the train which departs from Cicalengka station, ie walking, paratransit, ojek, and private vehicles (motorcycles). Considering there is only one latent variable for AM, and then automatically constructive formed to formative.

Independent variable is the perception of walkability (PW). Latent variables for PW consist of walking distance, availability sidewalk, convenient, safe from traffic, and safe from crime. These indicators are defined constructs, so that PW is also a formative construct.

From the previous studies, which states that there are residential self-selection and attitude-related travel, the concept is multi-dimensional. Residential self-selection is named as walk preferences (WP), the preference of walking to the selection of residential. The unique of each indicators for WP cause the construct not reflective but formative. Attitudes in the form of walking behavior beliefs (BB) as well as the WP also have an indicator that defines the construct, so that the indicators are also formative indicators. For all questions relating to PW, WP, and BB, respondents are required to provide an assessment of the requested agreement on 5-point Likert Scale from "strongly agree to strongly disagree".

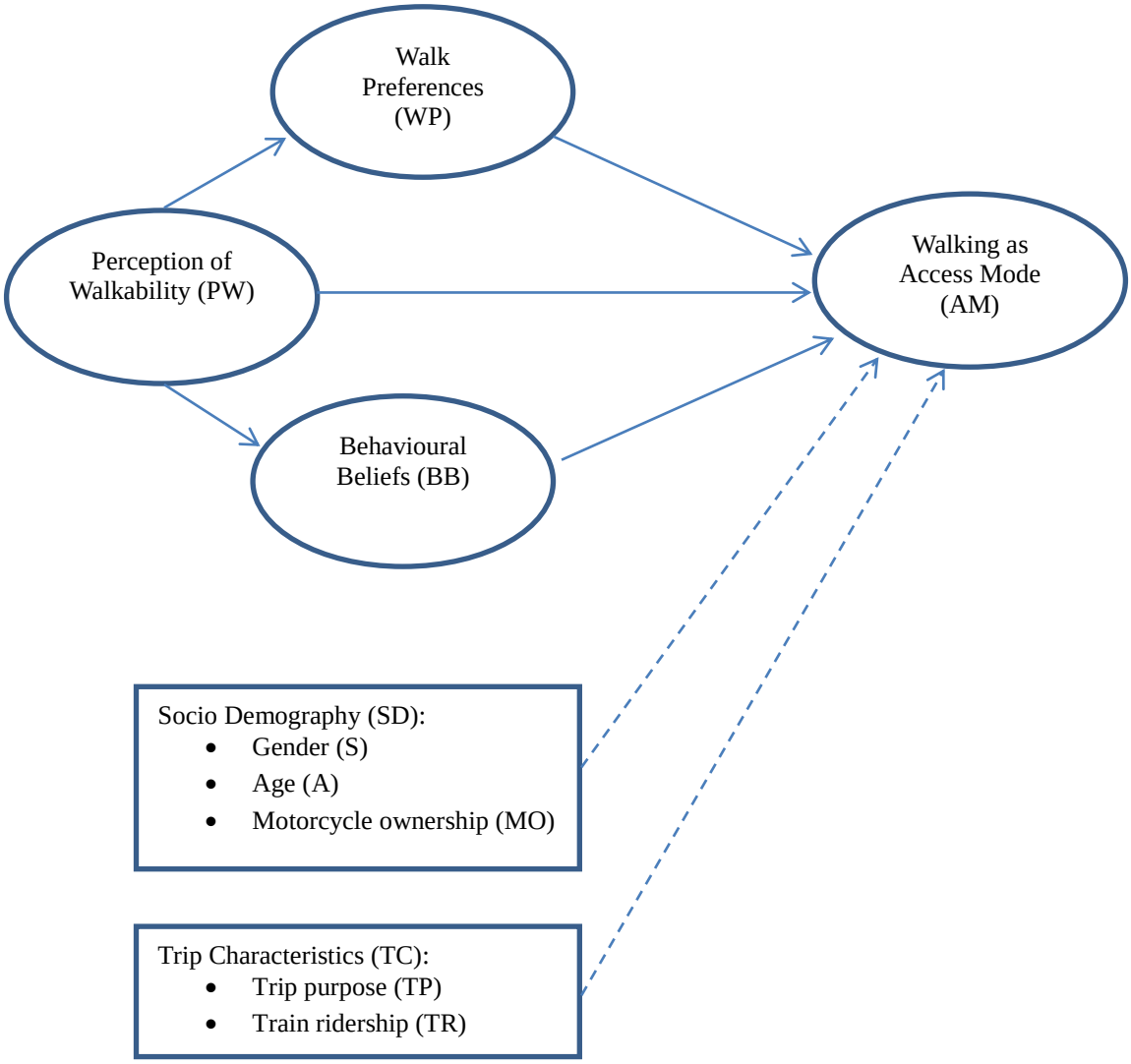
In the models predict the effect of walkability on the access mode choice, considering

the moderating effects of some socio-demographic characteristics, ie gender, age, and motorcycle ownership. Then, also tested the moderating effects of the trip characteristic, the trip purpose and train ridership. Test moderating effect of this will be done only if the direct correlation between PW and AM is significant.

Table 2. Variables

Variables	Formative Indicators	Data Scale
Dependent Variable: AM = access mode choice	Access mode	4 = walking, 3 = paratransit (angkot), 2 = ojek (informal public transport – motorcycle), 1 = private vehicle (car or motorcycle)
Independent Variable: PW = Perception of walkability	PW1 = The distance from home to the train station close to be reached by walking. PW2 = There are sidewalks or pedestrian paths from home to station. PW3 = Convenient to walk from home to the station. PW4 = The walk from the house to the station safe from motor vehicle traffic. PW5 = The walk from the house to the station safe from crime.	5 = strongly agree, 4 = agree, 3 = ordinary 5 = strongly agree, 4 = agree, 3 = ordinary, 2 = disagree, 1 = strongly disagree
Mediator Variable: WP = Walk Preferences	WP1 = Leisure walking is an important factor in choosing a neighborhood to live now. WP2 = Accessibility of public transport is an important factor in choosing a neighborhood to live now.	5 = strongly agree, 4 = agree, 3 = ordinary, 2 = disagree, 1 = strongly disagree
BB = Behavioural belief	BB1 = I like walking because healthy. BB2 = I like walking because it is cheap. BB3 = I like walking because it is fun. BB4 = I like walking because of practical.	5 = strongly agree, 4 = agree, 3 = ordinary, 2 = disagree, 1 = strongly disagree
Variables	**Indicators**	**Data Scale**
Moderator Variable: SD = socio-demography	SD1 = Gender SD2 = Age (year) SD3 = Motorcycle ownership	1 = male,0 = female 1 = 17 – 25, 2 = 26 – 50, 3 = more than 50 1 = have, 0 = do not have
TC = trip characteristics	TC1 = Trip purpose TC2 = Train ridership	4 = work, 3 = school, 2 = shopping, 1 = others 5 = very often, 4 = often, 3 = ordinary, 2 = rare, 1 = very rare

The correlation pattern that was analyzed in this study is like a conceptual model that can be seen in Figure 1.

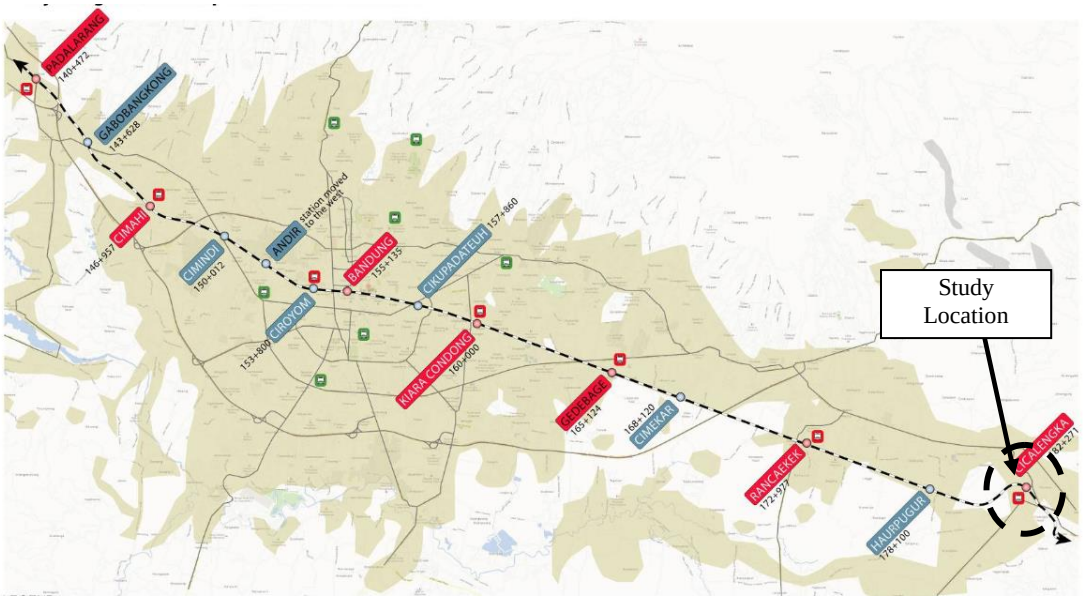


Note:
AM = dependent variable
PW = independent variable
WP and BB = mediator variable
SD and TC = moderator variable

Figure 1. Conceptual Model

4. DATA

Cicalengka station is one of the stations that serve the movement in Bandung Metropolitan Area by the Local Train Bandung Raya. Cicalengka station is located on the outskirts of Bandung Regency. This station is one of the stations that have a multimodal activity. Applicable tariffs are very affordable, which is Rp. 4,000 to Bandung station and Rp. 8,000 after the Bandung station until at Padalarang.



Source: Kajian Operasional Perbaikan Jalur Kereta Api Padalarang – BANDUNG – Cicalengka, 2011

Figure 2. Study Location

The amount of data is 135 sets for all variables. Most train users use paratransit as access mode (45.93%). Compared with the use of private vehicles, who choose walking is not much even the least choose and almost the same as the use of motorcycles taxi (ojek).

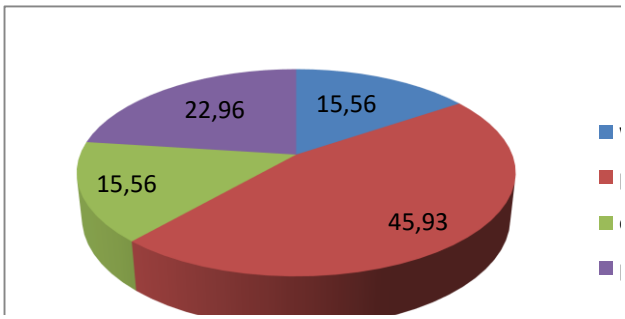


Figure 3. Access Mode Share

When viewed from the respondents' answers to PW, WP, and BB, not many who give answers 'disagree'. For some variables, nobody even answers 'strongly disagree'. Most give 'strongly agree' and 'agree' answers. This fact shows that, they provide a positive assessment for all variables.

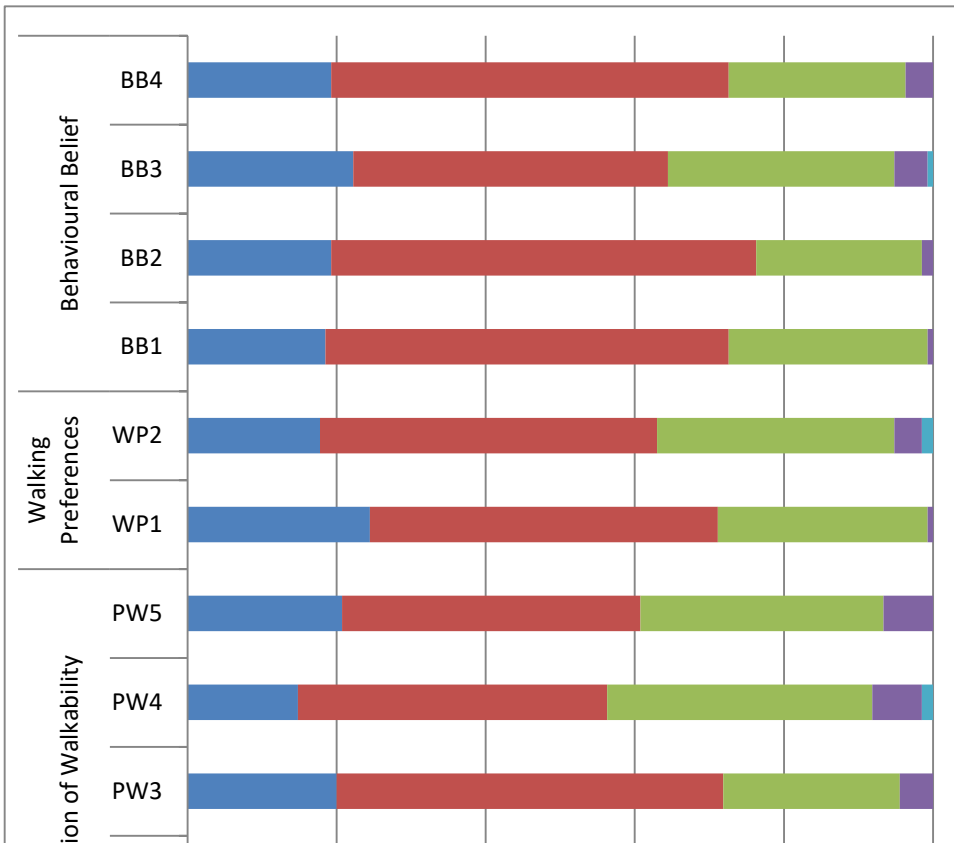


Figure 4. Proportion of Respondents' Answers to Perception of Walkability, Walking Preferences, and Behavioral Belief

The data is processed only for rail users who agree that the distance from home to the train station can be reached by walking. However, the proximity did not all respond strongly agree with the assessment, there is the usual answer. Of the three options given to PW1, which is an indicator for the distance, the "ordinary", "agree" and "strongly agree", the majority answered 'ordinary'. Meanwhile, for the other indicators PW given five answer choices, and mostly answered "agree". Likewise for the indicators WP and BB, most states "agree".

For gender (SD1), men are more than women, but the differences are not too far away. The age of the respondents (SD2) are mostly in the range of 26-50 years. More than 75% of respondents have a motorcycle.

Most trip purpose (TC1) is for the sake of work. Meanwhile, to train ridership (TC2) most widely expressed "very often".

For the modes used towards the train station (AM) at most answered with paratransit. It seems nothing to do with the answer PW1 (distance), which is largely answered “ordinary”.

5. DISCUSSION

The analysis must consider the formative measurement model collinearity indicators. Each indicator tolerance can be tolerated, if VIF ranging between <3 and <10. Table 3 shows all the indicators have a value of less than 3 and 10, means no collinearity. Rating previous test each

indicator based on the weight and outer loading. When the outer significant weight indicator, the indicator must be maintained. When the outer weight is not significant but the outer significant loading, the indicators maintained. In addition, if the outer and the outer weight loading is not significant and is not supported empirically, the indicator must be removed. If the conceptual theory is retaining the indicator, then the formative constructs maintained. Based on Table 3, all indicators in the formative constructs must be maintained as a significant indicator of the weight outer, outer loading, and theory-driven conceptual support.

Table 3. Formative Measurement Model

Keterangan	Outer Weights	T Statistics	VIF	Outer loading	T Statistics
AM -> Acces Mode Chioce (AM)	1			1	
BB1 -> Behavioural Beliefs (BB)	0.864741	2.888067	1.480	0.93949	5.296886
BB2 -> Behavioural Beliefs (BB)	0.39936	1.22411	1.401	0.690677	2.803539
BB3 -> Behavioural Beliefs (BB)	-0.142278	0.388581	1.595	0.403673	1.315989
BB4 -> Behavioural Beliefs (BB)	-0.081434	0.273011	1.504	0.378353	1.438765
PW1 -> Perception of Walkability (PW)	0.307048	1.271377	1.112	0.518951	2.23575
PW2 -> Perception of Walkability (PW)	0.157276	0.647581	1.253	0.451637	1.893499
PW3 -> Perception of Walkability (PW)	0.490665	1.255848	1.992	0.843238	4.162403
PW4 -> Perception of Walkability (PW)	0.489492	1.857649	1.724	0.855151	5.372191
PW5 -> Perception of Walkability (PW)	-0.122606	0.419617	1.642	0.511492	2.474051
WP1 -> Walk Prerference (WP)	1.016701	3.152519	1.116	0.998578	4.210686
WP2 -> Walk Prerference (WP)	-0.056317	0.113071	1.116	0.27087	0.602795

Source: The result of data processing

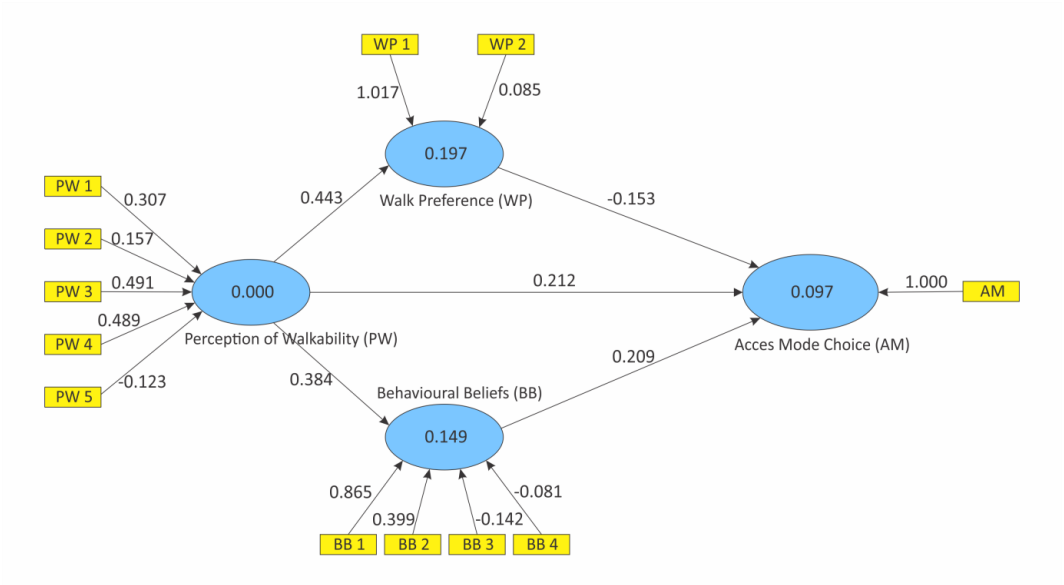
Even the indicator can be maintained, apparently the R-square is weak. This R-square show the predicted strength of the structural model for each endogenous variable. Hair (2014), if the value is 0,25 ‘weak’, 0,50 ‘moderate’, and 0,75 ‘strong’. This studu has three endogenous variables which is Access Mode Choice (AM) (R2 = 0,097), Behavior Belief (BB) (R2 = 0,1475), and Walk Preference (WP) (R2 = 0,1966), overall, the value generated r square is in the category of weak.

Table 4. R-square Endogen Variables

	R Square
Acces Mode Chioce (AM)	0.097482
Behavioural Beliefs (BB)	0.147512
Perception of Walkability (PW)	
Walk Preference (WP)	0.196608

Source: The result of data processing

The illustration of the relationship of each path can be seen in Figure 5.



Source: The result of data processing

Figure 5. Structural Model Testing Results

Thus, there is almost no influence (very weak) PW which is a representation of the built environment at the access mode choice. If return visits descriptive statistical analysis result, which illustrates that the vast majority stated mileage is 'ordinary' and 'agree' to indicators PW others, while they are more use paratransit, and not run, it's impossible to be explained.

As the R-square is weak, some formative indicators found unsignificant, because the T-Value is less than 1,96 (n=135, α = 5%). There are our indicators that is unsignificant, there are BB3, BB4, PW2, and WP2.

Table 5. Path Coefficients (Mean, STDEV, T-Values)

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Standard Error (STERR)**	**T Statistics (|O/STERR|)**	**Signifi-cances**
AM -> Acces Mode Chioce (AM)	1	1	0			
BB1 -> Behavioural Beliefs (BB)	0.93949	0.819831	0.177367	0.177367	5.296886	Significant

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)	Signifi-cances
BB2 -> Behavioural Beliefs (BB)	0.690677	0.590671	0.246359	0.246359	2.803539	Significant
BB3 -> Behavioural Beliefs (BB)	0.403673	0.405147	0.306745	0.306745	1.315989	Not Significant
BB4 -> Behavioural Beliefs (BB)	0.378353	0.374856	0.26297	0.26297	1.438765	Not Significant
PW1 -> Perception of Walkability (PW)	0.518951	0.455118	0.232115	0.232115	2.23575	Significant
PW2 -> Perception of Walkability (PW)	0.451637	0.389563	0.23852	0.23852	1.893499	Not Significant
PW3 -> Perception of Walkability (PW)	0.843238	0.729747	0.202584	0.202584	4.162403	Significant
PW4 -> Perception of Walkability (PW)	0.855151	0.752809	0.159181	0.159181	5.372191	Significant
PW5 -> Perception of Walkability (PW)	0.511492	0.437666	0.206743	0.206743	2.474051	Significant
WP1 -> Walk Prerference (WP)	0.998578	0.853756	0.237153	0.237153	4.210686	Significant
WP2 -> Walk Prerference (WP)	0.27087	0.251685	0.449356	0.449356	0.602795	Not Significant

Source: The result of data processing

As there are more than one (four indicators) unsignificant, then theoretically the formative constructs cannot be tested further in the structural model. T-statistic and R-square is in a low potential to reduce the predicted effects of causality between the constructs. Therefore, do not test the mediating effect. However, if you tried to moderate the effects, the result is as the following table.

Table 6. Moderating Variable Recap

Endogen Variables	R-Square Moderator Variables				
	Gender	Age	Motorcycle Ownership	Trip Purpose	Train Ridership
Acces Mode Chioce (AM)	0.152316	0.135794	0.20325	0.108077	0.135103
Behavior Beliefs (BB)	0.147512	0.147512	0.147512	0.147512	0.147512
Walk Prerferences (WP)	0.196608	0.196608	0.196608	0.196608	0.196608
T Statistik	1.75186	1.048242	1.435189	0.499281	0.910236

Source: The result of data processing

The biggest T value is gender, 1,75. If the condition of indicator formative construct everything is significant, it can be said there is an interaction between the perceptions of walkability with gender in influencing the endogenous variables.

6. CONCLUSION

By using formative indicators to construct in predicting the influence of perception of walkability, walk preferences, and behavior beliefs in access mode choice for users train ride from Cicalengka station, Indonesia, and residing around the station, indicating that not all of formative indicators have construct validity of test results significantly. Meanwhile, formative

constructs nothing should be removed because it will cause a loss of meaning and research would lose basic testing purposes. R-square value perceptions of walkability on the endogenous variables are also low. From the analysis, it can be concluded that the predicted effects of causality between the perception of walkability, walk preferences, beliefs and behavior of the access mode choice is very low. While seen in relative terms, gender variables have the greatest interaction with the perception of walkability in affecting other variables.

The main weakness of this study is the too high trust for the condition of this data. The model predictions need to be tested with lower levels of trust, for example, is 90%. The other drawback is the limited number of indicators that could affect the analysis. It could also use other methods to look at the relationship built environment, residential self-selection, and attitude associated with travel to the access mode choice.

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